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Evaluating the effectiveness of two training formats for grain dust explosion prevention

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ABSTRACT

Grain dust explosions result in fatalities, injuries, and downtimes in industry operations. Industry training has been implemented to educate workers on grain dust hazards and prevention tools and methods but no comprehensive evaluation has taken place. This research used the decision-making simulation to evaluate the effectiveness of two training formats for grain dust explosion programming using a four-level Kirkpatrick evaluation model. In addition, the association between the format of training and the decision choices made by workers and the information they used to make decision choices were examined. This research also examined the association between workers' level of perceived training effectiveness and the decision choices made by workers and the information they used to make decision choices. A web-based survey was used as a platform for the decision-making simulation. The survey was sent to 260 individuals who had completed an online or face-to-face grain dust explosion prevention training. Results from this research suggest that both the online and face-to-face training were effective in terms of delivering knowledge and increasing the awareness of grain dust hazards. The format of training was not found to be significantly associated with workers' decision choices and information used to make a decision choice. Similarly, workers' level of perceived training effectiveness was not found to be significantly associated with workers decision choices and information used to make a decision choice. Implications and recommendations for the grain dust explosion prevention training offered in online and face-to-face formats are shared.

Keywords: *Evaluation, Effectiveness, Grain dust explosions, Training.*

CHAPTER 1. INTRODUCTION

Grain dust explosions are a pervasive hazard in the grain handing and processing industry (Sanghi and Ambrose, 2016). Online and face-to-face training has been offered to educate workers on grain dust hazards and prevention tools and methods. Training is an important mitigation and hazard prevention method and is a critical component of worker safety. The purpose of this study was to evaluate the grain dust explosion prevention training offered in online and face-to-face formats using decision-making simulation. The use of the decision-making simulation to evaluate grain dust explosion prevention training measures not only the effectiveness in terms of awareness and knowledge of grain dust hazards, but also the ability of trainees to apply their knowledge in a realistic grain dust-related situation.

Rationale

Grain dust explosions have wide ranging effects such as fatalities, injuries, and facility downtimes. Effective training programs are an important prevention and mitigation method for grain dust explosions, educating workers on how to handle and process grain safely, minimize fugitive grain dust, and increase awareness of grain dust hazards.

Study Objectives

The objectives of this study were to measure the effectiveness of two formats of grain dust explosion prevention training with decision-making simulation and to evaluate the training program using the four-level Kirkpatrick evaluation model. The decision-making simulation was intended to:

- Measure the decision choices made by workers who have taken an online or face-to-face training in preventing grain dust explosions.

- Measure the information used to make a decision choice by workers who have taken an online or face-to-face training in preventing grain dust explosion

Long Term Goal

The long-term goal of this study is to identify continuous improvement opportunities for existing grain dust explosion prevention workplace training programs while using a behavioral based active learning approach, which in turn is expected to lower injury and fatality rates and number of grain dust explosions. In addition, the evaluation of the training could help workers become more aware and review actions necessary for positive safety outcomes.

Research Questions

This study was guided by the following research questions:

1) Does the format of grain dust explosion prevention training influence workers' safety-oriented decision-making choice?
2) Does the format of grain dust explosion prevention training influence the information workers' use to make decision choices?
3) Does the level of perceived training effectiveness determine the decision choices people who work with grain dust hazards make?
4) Does the level of perceived training effectiveness determine the information people who work with grain dust hazards use to make decision choices?

CHAPTER 2. LITERATURE REVIEW

The literature review will address five areas. These areas include: 1) evaluating the effectiveness of safety training programs; 2) the four-level Kirkpatrick evaluation model; 3) survey development; 4) dust explosions; and 5) grain dust explosion prevention training materials. This literature review is important for providing a basis for the research undertaken. However, the topics discussed are not comprehensive but represent a synopsis of findings in the evaluation of safety training programs focused on prevention of grain dust explosion in online and face-to-face formats.

Evaluating the Effectiveness of Safety Training Programs

Grain dust explosion hazards impact grain handling and processing facilities and the workers in these organizations. Training programs play a critical role in educating workers on how to work safely. However, several challenges exist. These challenges include getting grain handling workers to take dust seriously as a safety hazard (Burke, Salvador, Smith-Crowe, Salvador, Chan-Serafin, 2011; Amyotte, 2014), management support, and workers' attitude towards training (Choudhry & Fang, 2008). Training is costly and time-consuming for both employees and managers. For this reason, evaluation plays a crucial role in determining the effectiveness and impact of the training programs (Smidt, Balandin, Sigafoos, & Reed, 2009).

Evaluation is also important because it allows the trainer to identify continuous improvement opportunities such as addressing certain topics in the training that trainees may be struggling with in more depth. The evaluation of impact and effectiveness of training play an essential role in identifying strengths and weaknesses so that improvements can be carried out. Schuh, Biddix, Dean, and Kinzie (2016) define effectiveness as a measure of an extent to which a program, activity, or learning experience achieves its goals. Effectiveness in this research is important because it can provide information on how well training has met the needs and objectives of participants enabling them to perform safely in the workplace. In this study, the effectiveness of grain dust explosion prevention training was measured by participants ability to make safety-oriented decision choices based on selected hypothetical, but realistic grain dust related scenarios.

Four-level Kirkpatrick Evaluation Model

One approach to evaluating program effectiveness is the four-level Kirkpatrick evaluation model developed by Donald Kirkpatrick. The model has been used to assess training effectiveness in organizational programs (Praslova, 2010). The four-level Kirkpatrick evaluation model is useful for adult education programming, because it provides useful and specific information about the effectiveness of training from several perspectives. According to Smidt et al. (2009) the model can be used to determine whether a training program met the needs and requirements of the organization implementing a given training program and of the participants in the training program. The four-level Kirkpatrick evaluation model consists of reaction, learning, behavior, and results (Smidt et al., 2009).

Level 1: Reaction

The first level of the Kirkpatrick evaluation model examines reaction (Kirkpatrick, 2007). This level evaluates participants' impressions of training and is typically presented to participants at the end of a training program (Smidt et al., 2009). Such evaluation is important because of its capability of providing direct feedback on the participant's satisfaction with training. For this reason, level one (reaction) evaluation has been widely used by many organizations (Rouse, 2011). The ease of collection is one potential reason for its wide use according to Arthur, Bennet, Edens, and Bell (2003). While level one evaluation has been widely used by many organizations, it lacks the ability to evaluate participants' learning (Smidt et al., 2009). Therefore, solely evaluating level one is not enough to provide sufficient information on whether a training session is effective. Kirkpatrick stresses that the evaluation should extend beyond reactions from trainees (Rouse, 2011).

Level one (reaction) responses were determined in the grain dust training sessions using a paper-based survey, asking how well attendees were satisfied with the training and how useful they found the training to be. In this study, participants were also asked how useful the grain dust training sessions were to them but with a slightly different approach, described later. The implication from evaluating level one (reaction) could provide trainers information on whether participants were interested, motivated, and/or engaged in the training (Smidt et al., 2009). This is important to participant's learning because studies have shown that learners with strong motivation and interest may learn more (Daskalovska, Gudeva, & Ivanovska, 2012).

Level 2: Learning

The second level of the Kirkpatrick evaluation model measures participants' learning in terms of knowledge and/or skills gained and whether the learning objectives were met (Smidt et al., 2009; Kirkpatrick, 2007). Pre/post tests are generally used to measure trainee learning. Arthur, Tubre, Paul, and Edens (2003) point out that pre/post tests offer the most direct measurement of learning. This approach typically includes group and individual exams, tests, role-playing tasks, or surveys. The evaluation of whether the learning objectives were met is important for two reasons according to Kirkpatrick (2007): (1) the evaluation of learning provides feedback on the effectiveness of the instructor in increasing knowledge and changing attitudes of trainees, and (2) the evaluation helps instructors identify where they have succeeded in their training by examining the change in answers in the tests given to trainees and what portions of the training program require improvement. If the training program were to repeat again, instructors would be able to address the gaps identified from the evaluation to increase the chances that learning will take place.

Level two (learning) responses were determined in the grain dust training sessions using a pre/post test by testing participants pre-knowledge of grain dust explosion prevention prior to taking the training and post knowledge of grain dust explosion prevention after taking the training. The implication from evaluating level two (learning) could help trainers not only determine whether participants are acquiring the knowledge and/or skills from the training but identify potential learning gaps and addressing them to improve participants learning.

Level 3: Behavior

The third level of the Kirkpatrick evaluation model examines behavior (Kirkpatrick, 2007). Smidt et al. (2009) define this level as the ability to apply newly learned knowledge and/or skill in an authentic setting. The primary goal of level three evaluation is to assess whether behavior changed as a result of training and this can be accomplished through observation or testing. Behavior change is critical because it provides information on whether individuals were able to transfer newly learned knowledge and/or skills into a realistic setting. Praslova (2010) comments that this level can identify the effects of training as well as measure performance in a realistic environment.

Level three (behavior) was measured in this study using a decision-making simulation to examine workers decision-making process when given a realistic scenario. The implication from evaluating level three (behavior) could provide trainers information on whether the material participants learned could be used in a practical and realistic environment. Kirkpatrick (2007) commented that if no change in behavior was found, then a probable conclusion would be that no learning took place.

Level 4: Results

The fourth level of the Kirkpatrick evaluation model examines results. This level focuses on measuring the long-term impacts that the training could potentially provide, and this could be in terms of financial or morale impacts (Smidt et al. 2009). In a safety context, this could mean lower injury and/or fatality rates or that behavior has shifted so that it is more safety-oriented than previously. Praslova (2010) noted that while these results are challenging to evaluate they are highly desirable because it could help trainers identify the impacts of training overall.

Level four (results) was measured in this study by examining open-ended comments provided by workers on whether they have done anything different at the workplace as a result of the grain dust training. The implication from evaluating level four (results) could help trainers identify whether participants learned. Level four also measures if the trainees not only are able to apply their newly learned knowledge and/or skill in a realistic setting as a result of training, but that they are applying the newly learned behavior consistently.

The four-level Kirkpatrick evaluation model is a well-known approach and has been used in many organizational settings (Rajeev, Madan, & Jayarajan, 2009). Mosher, Freeman, and Hurburgh (2011) have used the four-level Kirkpatrick evaluation model to determine the usefulness of the online course in Quality Management Systems for adult learners and to identify continuous improvement opportunities. Each level of the four-level Kirkpatrick evaluation model was applied. Levels one and two were previously evaluated and required by OSHA. In this study, levels three and four evaluations were focused.

The popularity of the four-level Kirkpatrick evaluation model can be explained by several factors. First, this model provides a clear system or language for communicating about training outcomes and information that can be provided to measure the extent to which training programs have met certain objectives. Second, the information provided from a four-level evaluation is perhaps the most valuable or descriptive information about training that can be acquired, providing a holistic evaluation of several short term and long-term aspects of the training. Finally, the four-level Kirkpatrick evaluation model provides a simple process of training evaluation (Bates, 2004). The four-level Kirkpatrick evaluation model is a well-suited method to evaluate adult education because of its ability to assess whether adult learners can apply their newly learned knowledge and skill from training on a realistic task.

This is important because while adult learners can acquire the knowledge and/or skills from the training, this does not mean they can apply what they have learned in a realistic setting (Rouse, 2011). On-the-job application of knowledge and skills in preventing grain dust explosions are especially important to limiting the chances of grain dust explosions that could result in worker injuries, fatalities, and facility downtimes. In this study, the four-level Kirkpatrick evaluation model was used as a framework to evaluate the effectiveness of grain dust explosion prevention training offered in online and face-to-face formats.

Decision Process Tracing Methodology

Conventional learner assessments such as multiple-choice tests or quizzes capture learning in terms of knowledge and skills. However, these assessments are unable to measure an individual's ability to apply newly learned knowledge and skills to a realistic task

(Mueller, 2005). Understanding behavior change or the ability of trainees to apply newly learned knowledge and skills in a realistic task can help determine the effects of training on work performance (Praslova, 2010). This is important because the implication from understanding whether trainees have the ability to apply newly learned knowledge and skills in a realistic task allows trainers to identify potential learning gaps and make needed improvements to the training to address those gaps.

Previous research has suggested that workers are aware of the hazards in the grain handling and processing industry, however incidents still occur (Walker, 2010; Mosher, Keren, Freeman, & Hurburgh, 2014). To better understand why employees make unsafe decision choices when they appear to be fully aware of safety hazards, an in-depth understanding of the decision-making process is necessary (Mosher et al., 2014).

To measure the employee decision-making process is not a straightforward process, Mosher et al. (2014) utilized the decision process tracing methodology; an approach used to measure the information used to form a judgement and the sequence in which the information was evaluated. Using this approach, the data gathered can then be used to characterize the decision-making process (Ford, Schmitt, Schechtman, Hults, & Doherty, 1989). Process tracing has also been used by Keren, Mills, Freeman, and Shelley (2009) to examine the relationship between level of safety climate and orientation toward safety in the decision-making process. Mosher, Keren, Freeman, and Hurburgh (2012) used the process tracing methodology to examine decision-making patterns of grain elevator workers regarding safety and quality.

The decision process tracing methodology is well suited to evaluating the effectiveness of safety programming, having the ability to recognize specific decision rules and models used in the decision-making process, as well test the association of situational and personal variables with the decision choice and its outcome (Mintz, 2004). This is important when measuring program effectiveness because having a better understanding of how workers make decision choices can provide useful information on whether the training was effective in delivering the knowledge and increasing the awareness of grain dust hazards. In this study, the process tracing methodology was modified to measure the decision-making process of workers who have participated in an online or face-to-face grain dust explosion prevention training using Qualtrics, a web-based survey software.

The decision-making simulation approach is helpful at gaining an insight of factors that influence the information workers use to make safe decisions (Mosher et al., 2014). While previous studies have used the decision-making simulation to examine safety-decision-making patterns in grain handling and industrial environments (Mosher et al., 2014; Keren et al., 2009), the use of the approach is limited in the context of grain dust explosions. In this study, workers' decision-making choice and the information they used to make the decision choice were measured through the decision-making simulation.

To measure how workers might respond in a safety sensitive scenario related to grain dust hazards, decision choices were created and provided in each scenario for workers to choose from. In addition, potential factors driving the decision choice were created and provided in each scenario for workers to rank. Survey questions were developed to measure workers perception of the usefulness of the grain dust explosion prevention training. These questions include: 1) to what extent did you use your grain dust explosion prevention training in answering the scenarios? 2) Was the training helpful? 3) How would you rank grain dust in terms of its safety hazards? And 4) How much control do you have now on mitigating grain dust explosions?

The usefulness of the training was measured to determine whether the training was helpful to workers in making safety-oriented decision choices. This is important because it allows trainers to identify continuous improvement opportunities for the training. At the end of the survey, workers were provided an opportunity to comment on the question of whether they have done anything different at the workplace after taking the training. This question was included in the survey to examine whether workers were able to apply newly learned knowledge and or skill in a realistic environment as a result of the training. This is important because it allows trainers to determine whether learning took place.

Grain Dust Explosions

Grain elevators, feed mills, flour mills, and other processors experience between 9 and 10 grain dust explosions per year according to data collected by Ambrose (2017). Grain dust explosions are a well-known hazard in the grain industry and when they occur many negative outcomes result including employee fatalities, injuries, property loss, and business interruptions.

Factors and conditions driving grain dust explosions are well known and understood, in part through the use of the grain dust explosion pentagon (Abbasi & Abbasi, 2007; Sanghi & Ambrose, 2016). The pentagon includes the elements of dust, dispersion, confinement, oxygen, and an ignition source as shown in Figure 1. The pentagon illustrates that when all five elements come together, an explosion can occur. Four of the five elements, i.e., fuel, dispersion, confinement, and oxygen are often present in a grain handling environment and the fifth, an ignition source can appear suddenly. The fuel in the case of grain handling is grain dust. Several examples of ignition sources include welding and other hot work, a misaligned belt in a bucket elevator, overheated bearings, and static electricity (Sanghi & Ambrose, 2016).

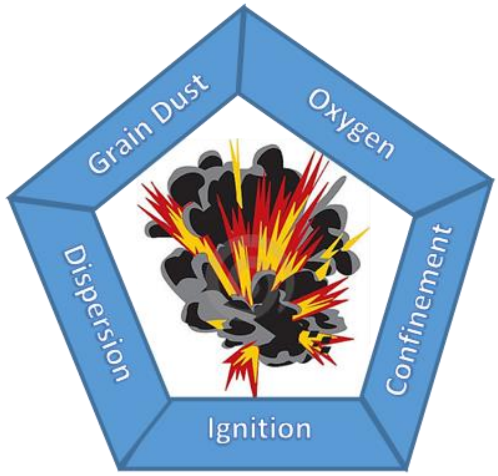

Figure 1. Grain dust explosion pentagon. Reproduced from "Agricultural Dust Explosions" by Ambrose, R.P.K., 2017. Internal document from Purdue University.

A primary way to control combustible dust hazards in grain handling facilities has been through consistent housekeeping. As part of the hierarchy of controls, removing the hazard (dust) from the facility is a key method of preventing grain dust explosions or at least mitigating the effects (Amyotte & Eckhoff, 2010). In addition, maintaining equipment used for grain handling and processing play an essential role in preventing grain dust explosions because adequate equipment design and management can prevent a malfunction from becoming a potential ignition source (Sanghi & Ambrose, 2016). These efforts to effectively prevent grain dust explosions rely largely on workers and their knowledge of the hazards of grain dust (Amyotte, 2014).

Grain Dust Explosion Prevention Training Materials

Through a grant from the U.S. Department of Labor, Occupational Safety and Health Administration's (OSHA) Susan Harwood Program, Iowa State University and Purdue University personnel developed a set of learning materials on grain dust explosion prevention that can be used for face-to-face training of grain elevator employees. The purpose of the Susan Harwood Grant Program is to provide training and education programs for employers and workers on workplace safety and health hazards, responsibilities, and rights. Face-to-face training on grain dust explosions has been offered since 2013, first by Kansas State University and later by Iowa State University and Purdue University to grain elevator workers. The program has trained nearly 500 workers since 2015.

The four-hour training consists of five modules focused on increasing the awareness of grain dust hazards and the prevention of grain dust explosions. A live demonstration of a grain dust explosion using an explosion chamber is also used to allow trainees to see the process of an explosion. Modules are described in Table 1. The target audience for this training include workers and employers involved in grain handling operations as well as those who work at flour and feed mills. A second training program has also addressed the need for grain dust hazard awareness and prevention. The Grain Elevator Processing Society (GEAPS), a professional association of grain industry employees, serves as a knowledge resource for the grain handling and processing industry. A distance (online) course on grain dust explosion prevention entitled Preventing and Responding to Grain Dust Explosions (GEAPS 544) was developed by GEAPS in 2013. The goal of this course was to provide a comprehensive overview of contributing factors in grain dust explosions, preventive measures, control measures, and appropriate responses to a grain dust explosion. The 5-week course consists of 10 units. A description of the units is provided in Table 2.

Table 1. Description of face-to-face training modules

Topics	Module Description
Module 1 Introduction to Grain Dust Explosions	Overview of past grain dust explosion incidents; five elements for a grain dust explosion to occur, ignition sources, and primary and secondary explosions
Module 2 Grain Dust Properties; Unloading Grains	Combustibility of grain dust; control of dust generation during unloading; appropriate control devices to limit dust generation during unloading
Module 3 Good Housekeeping Practices; Preventive Measures	Good housekeeping practices, managing dust levels; preventive maintenance of dust control machinery components
Module 4 Preventive Maintenance; Material Handling	Need for equipment maintenance; safe transfer of grain; use of proper equipment for grain conveying and handling
Module 5 Advanced Engineering Controls	Safety precautions for bucket elevators; use of appropriate sensors in bucket elevators; managing bearing sensors; dust suppression devices

Table 2. Description of online training units

Topics	Unit Description
Unit 1 Historical Grain Dust Explosions and Inevitable Consequences	Overview of the potentially disastrous consequences of grain dust explosions; risks faced by industry and workers; past grain dust explosion incidents
Unit 2 Combustible Dust	Origin and types of grain dust causes of grain dust explosions, ignition sources, and factors needed for a grain dust explosion
Unit 3 Grain Handling and Dust	Dust generation from grain handling; overview of grain dust properties, types of dusts; understanding machinery hazards
Unit 4 Housekeeping as a Control Mechanism	Importance of housekeeping; identifying dust hazards; the use of dust collection systems
Unit 5 Grain Dust Regulations	Key regulations designed to prevent dust explosions and using a safety checklist to assist in prevention of grain dust explosions
Unit 6 Preventive Maintenance	Utilizing hazard monitoring systems and engineering controls to prevent explosions; preventive maintenance of machinery components
Unit 7 Practices and Techniques to Avoid Generating Dust	Implementing grain handling practices and techniques to avoid generating dust
Unit 8 Preventing Dust via Facility and Equipment Design	Using facility and equipment systems to help reduce potential hazards of grain dust explosions
Unit 9 Preventive Training	Importance of training workers, contractors and others on the risks of grain dust explosions; creating an emergency action plan; the value of developing a good training plan
Unit 10 There’s Been an Explosion. What Now?	How companies will need to respond immediately after a grain dust explosion has occurred

The online training course has been offered for the last four years to grain elevator employees and has had a total enrollment of nearly 178 employees. The target audience for the online course includes managers responsible for safety at grain facilities, local and regional managers, superintendents, contactors, new employees in the grain industry, and others with a need to know about preventing grain dust explosions.

The topics that were covered in online and face-to-face training were similar. These topics include an overview of past incidents of grain dust explosions and their consequences, the elements needed for a grain dust explosion to occur/explosion pentagon, sources of dust generation and grain dust properties, grain dust regulations, practices and techniques/proper material handling techniques to avoiding creation of dust, and most importantly housekeeping and maintenance which are essential when it comes to preventing grain dust explosions. According to Ambrose (2018), keeping the facility clean, training workers and contractors, keeping equipment in good working condition by preventive maintenance, using grain dust explosion suppression and venting systems are positive prevention practices.

While there were similarities in terms of the topics covered in online and face-to-face training, there were several differences as well. First, face-to-face training addressed the potential challenges workers may encounter when implementing housekeeping and preventive measures. These were not addressed at length in the online training. Second, online training addressed the importance of preventive training and how companies should respond immediately after a grain dust explosion has occurred. These were not covered at length in the face-to-face training. Third, the use of a safety audit checklist to assist in preventing grain dust explosion were addressed in the online training but was not addressed at length in the face-to-face training.

Online and face-to-face training on mitigating grain dust explosions are important to providing workers the awareness and knowledge on preventing and mitigating grain dust explosions however grain dust explosions are just one of several hazards workers may face in the grain handling and processing industry. Grain elevator facilities hold a variety of hazards and accidents prevalent to many other workplaces such as strain/sprain, slip/trip, falls, cut/pinch, respiratory hazards, fire, and serious injuries and fatalities caused by improper lockout tagout and confined space entry (Seo, Torabi, Blair, and Ellis, 2004).

The grain handling and processing industry typically has 9 to 10 grain dust explosions per year (Ambrose, 2017). Yet, other hazards also demand attention of workers, supervisors, and management (Mosher et al., 2013). While grain dust explosions are not as frequent as other grain-related hazards, when they do occur they are high impact events. In addition, managing grain dust hazards are not a once-a-month or periodic activity, rather it involves a daily process of removing dust and equipment maintenance. For these reasons, increasing worker awareness of grain dust hazards is critical.

CHAPTER 3. METHODOLOGY

The purpose of this study was to evaluate the effectiveness of two formats of training on preventing grain dust explosions using the decision-making simulations. A web-based survey was developed and used as the platform for the simulations. The following research questions were addressed in this study:

1) Does the format of grain dust explosion prevention training influence workers' safety-oriented decision-making choice?
2) Does the format of grain dust explosion prevention training influence the information workers' use to make decision choices?
3) Does the level of perceived training effectiveness determine the decision choices people who work with grain dust hazards make?
4) Does the level of perceived training effectiveness determine the information people who work with grain dust hazards use to make decisions?

Establishing a Survey for the Decision-Making Simulation

A cross-sectional survey was carried out to evaluate the grain dust explosion prevention training in online and face-to-face formats. The survey questions were administered along with four decision-making scenarios to measure the decision choices of participants and the information they used in the decision-making process using Qualtrics™. Qualtrics is a web-based survey software and it was used to administer the survey and decision scenarios in this study. Andrews, Nonnecke, and Preece (2007) pointed out the flexibility web-based surveys provide to researchers in terms of design and noted an increase over the control of respondents' use of the survey. In addition, web-based surveys are inexpensive and quick to distribute. For these reasons, and because grain dust explosion prevention trainees were spread out throughout the U.S., Canada and other parts of the world, web-based-survey procedures were used in this study.

In each decision-making scenario, four decision choices and up to five contributing factors were presented, allowing respondents to determine their decision choices and rank contributing factors in order of influence that each had on the final choice. Contributing factors included items such as a low probability of a safety issue, personal safety concerns, supervisory pressure, peer pressure, job responsibilities, and the priority of work tasks, productivity, and time. The sequence of decision alternatives and contributing factors were randomized. Decision-making scenarios, decision alternatives, and contributing factors were presented to all online and face-to-face grain dust explosion prevention trainees.

Once trainees completed the decision simulation, they completed other information in the survey, including demographics such as gender, age, and highest level of education. Training usefulness questions were included in the survey to ask online and face-to-face trainees how useful the training was for them and how often they used information learned in the training sessions in their daily tasks. The purpose of these questions was to measure the workers' perception of training usefulness. These questions included: To what extent did you use your grain dust explosion prevention training in responding to the scenarios? Was the training helpful? How would you rank grain dust in terms of its safety hazard level? How much control do you have now on mitigating grain dust explosions?

At the end of the survey, trainees were provided the opportunity to comment on an open-ended question asking whether they had done anything different at the workplace after taking the grain dust mitigation training. The purpose of this question was to determine the impact that the grain dust training had on the workers' ability to apply what they had learned from the training in their respective workplaces. The survey was reviewed by three experts in grain handling and grain dust and was pilot-tested on feed processing and technology students at Iowa State University. Several revisions were made to the scenarios in terms of clarity and authenticity after the pilot-testing.

Decision-Making Simulation

The decision-making simulation was the survey instrument used in this study. Previous researchers (U.S. Chemical Safety and Hazard Investigation Board, 2005; Amyotte, Pegg, and Khan, 2009) have noted that inadequate maintenance and a lack of housekeeping were the primary causes of previous dust explosions. Further, Ambrose and Sanghi (2016) highlight the importance of good housekeeping practices, efficient dust collection, equipment maintenance, avoiding overloads of grain handling equipment, and effective training in preventing grain dust explosions. For this reason, four hypothetical scenarios were developed with a focus on housekeeping and equipment maintenance. The scenarios were created using experiences and opinions of grain industry experts and previous literature.

Decision scenarios were hypothetical but realistic situations that workers could face in their daily grain handling work tasks. For each scenario, workers were provided a range of decision choices with some having a strong safety-oriented and some focused on non-safety-oriented options. A safety-oriented decision choice in this case would be defined as best practices of grain dust explosion prevention, as addressed in the online or face-to-face training on preventing grain dust explosions. A non-safety-oriented decision choice in this case would be defined as practices not addressed in the online and face-to-face training on preventing grain dust explosions such as neglecting housekeeping tasks. These decision choices were developed based on the opinions and experiences of grain handling professionals and previous literature.

In the housekeeping scenario, workers were asked to make a decision choice regarding a request to perform housekeeping tasks. In the scenario, the supervisor tells them that housekeeping should be delayed and that the area was not dusty enough to make housekeeping a priority at that time. Workers selected from the following decision choices: 1) take time to immediately sweep the headhouse floor and clean the headhouse equipment; 2) think about the advice from the supervisor and try to persuade the supervisor to allocate some time later to complete housekeeping tasks in the headhouse; 3) assume someone else will clean up the dust; 4) promise to tackle cleaning before the end of the day, but never getting to it.

A safety-oriented decision choice would be to take time to immediately sweep the headhouse floor and clean the headhouse equipment in hopes to limiting the presence of dust to reduce the chance of dust cloud formations, preventing a grain dust explosion (Frank, 2004). In this case, the safety concern about grain dust being a safety hazard and that it should be managed accordingly was addressed. However, this choice may have negative implications for productivity because taking the time sweep and clean the headhouse could delay the completion of more important tasks. Findings from Mullen (2004) suggest that productivity is one of the underlying factors that often explain unsafe practices.

The next several decision choices are non-safety-oriented: thinking about how to persuade the supervisor to allocate time later to complete housekeeping tasks, assuming someone else will clean up, and promising to tackle cleaning before the end of the day, but never getting to it. While trying to persuade the supervisor to allocate time later to complete housekeeping tasks in the headhouse has safe individual intentions, trying to persuade the supervisor could have negative implications for supervisor response. In this case, where the worker has contradicted the supervisor's opinion that housekeeping can be delayed and that the area is not dusty enough to warrant making housekeeping a strong priority. This decision choice was included to examine how workers respond when a manager or supervisor suggest an action that is not safety-oriented. Previous literature suggests that management's actions directly influence workers' perceived safety climate, meaning if management were committed to safety then it was more likely that workers would demonstrate a commitment to safety (Mullen, 2004).

The next decision choice focused on worker responsibility. Assuming that someone else will clean up was an unsafe decision choice from a safety perspective. This decision choice refers to a phenomenon known in the literature as social-loafing, where it is about the reduction of effort on a task when in a group, assuming that others would pick up the slack (Jassawalla, Sashittal, & Malshe, 2009). In this case, workers reduced their effort of completing housekeeping tasks, assuming that others would complete the housekeeping task. This decision choice was included because both training programs emphasized the importance of housekeeping tasks as everyone's responsibility.

The next decision choice focused on promising to tackle cleaning before the end of the day, but never getting to it. This decision choice was non-safety oriented because delaying housekeeping tasks before the end of the day does not solve the issue of grain dust explosions and reflects the low priority grain dust hazards have in the overall safety plan for the facility. Continuous housekeeping and sanitation are crucial to mitigating grain dust explosions (Jones, 2011). This decision choice was included to reflect the many competing priorities workers have on their time at work. This choice connects with productivity and probability of real consequences resulting from an unsafe action. It also reflects the reality of many workers: that they have a lot of hazardous tasks to manage and prioritizing them is difficult (Walker, 2010). While they know that grain dust is hazardous, the chances of an explosion happening is slim, thus not making housekeeping tasks a high priority in their overall risk management. Previous research has found that perceived risk was positively associated with workers' willingness to adopt safer practices (Mullen, 2004).

In the maintenance scenario, a sensor alarm goes off indicating that a bearing temperature has reached a critical level. The colleague brushes off the alarm, telling you that it has gone off several times and nothing has happened. The worker suspects the bearings need grease, causing them to overheat. This scenario offers workers several decision choices: 1) follow the colleague's advice: keep the bucket elevator running; 2) take precautions: run the bucket elevator empty then turn it off and check the bearings; 3) false alarm: the bucket elevator is working just fine; 4) prevention of future alarms: stop using the bucket elevator until you can determine what is causing the bearing alarm to go off.

A safety-oriented decision choice would be to take precautions to avoid a dust-related incident. This decision choice was included not only because there was an indication of a problem, but because the purpose of a bearing temperature sensor is to provide an indicator of a safety hazard. An increase in the bearing temperature could result in a spark leading to a grain dust explosion. One of the potential ignition sources in a grain handling or processing facility is an overheated bearing (Sanghi & Ambrose, 2016), and this information was emphasized in the training sessions.

The next several decision choices are non-safety oriented: 1) prevention of future alarms; 2) follow the colleague's advice; 3) false alarm. While the prevention of future alarms has safe individual intentions, the decision choice may have negative implications for productivity if a full root cause analysis is performed for every alarm. Stopping the bucket elevator for every alarm could be interpreted as too cautious and limited work would be completed if the full stop process was stopped after every alarm. This decision choice was included to reflect the assumption that there must have been something wrong if the alarm was going off. Ignoring indicators that could have prevented an explosion have been shown to be a prevalent factor in post-explosion incident reports.

The next decision choice focused on following the advice from the colleague. This decision choice was non-safety oriented because following a colleague's advice of keeping the bucket elevator running while the bearing temperature has reached a critical level could lead to a potential grain dust explosion. This decision choice was included to test the influence of peer pressure in the safety decision. Peer pressure was found to be a significant factor in workers' decision-making choices by Keren, Mills, Freeman, and Shelly's (2009) study. Walker (2010) also discussed the relationship of peers to individual safety in his grain elevator-based research.

The next decision choice examines false alarms. Treating the alarm as false was a non-safety-oriented decision because the choice has negative implication for safety concerns. Again, it addresses the failure to take early indicators seriously and tests whether the workers perceive that something must be wrong if the bearing temperature alarm is going off. This decision choice was included to examine workers safety attitude and whether workers can identify that although the bucket elevator may be working just fine, there could be a problem. Taking early indicators seriously is part of the workers' safety attitude, which was found to be a factor explaining unsafe practices in Mullen's (2004) study.

The housekeeping shortcut and inadequate maintenance scenarios were included in the simulation to gain an understanding how individuals would respond to a safety shortcut opportunity related to grain dust hazards. Safety shortcut opportunities are common in all workplaces and the reaction of workers to short cut opportunities have been studied by other researchers (Keren et al., 2009; Walker, 2010; and Mosher et al., 2014).

In the housekeeping shortcut, workers were asked to make a decision choice after noticing an area in the gallery (bin deck) needed housekeeping. However, after speaking with the supervisor about the needed housekeeping, the supervisor says that housekeeping can wait until later and instructs the worker to sweep the dust underneath the conveyors. Workers were provided with following decision alternatives: 1) follow the supervisor's advice: sweep the dust underneath the conveyors for now; 2) promise to tackle the full cleaning procedure before the end of the day; 3) approach the supervisor, expressing to him the uncertainty of sweeping the dust underneath the conveyors; 4) stop working and take time to clean the area.

A safety-oriented decision choice would be to stop working and take time to clean the area to reduce the amount of the grain dust generated from grain handling and processing, preventing grain dust explosions. However, this choice may have negative implications for productivity and disobeying the supervisor's directive to delay the housekeeping task. This decision choice was included because it was assumed that workers know that even a little bit of grain dust can be hazardous. The training sessions emphasized the importance of housekeeping to keep dust levels down, thus preventing primary and secondary grain dust explosions.

The next several decision choices are non-safety oriented: 1) approaching the supervisor, expressing to him the uncertainty of sweeping the dust underneath the conveyors;

2) promising to tackle the full cleaning procedure before the end of the day; 3) following the supervisor's advice. Questioning your supervisor is a safety choice but may not be positive in terms of the relationship with the supervisor. This decision choice was included to test how workers would make a decision choice when a manager or supervisor directed them to act in an unsafe way. Working together with the supervisor to determine a more effective housekeeping strategy would improve the safety orientation of this choice.

The next decision choice looked at promising to tackle the full cleaning procedure before the end of the day. This decision choice, while it has safe intentions, was not a safety-oriented decision choice because the housekeeping task was not actually completed. Workers may have positive intentions about housekeeping, but unless they commit to completing the task, the safety hazard remains. Balancing housekeeping tasks among the many other hazards workers manage on a daily basis is a continuous challenge in the grain industry. The decision alternative was written to reflect this challenge.

The next decision choice focused on following the supervisor's advice. This decision choice was non-safety oriented. Following the supervisor's advice of sweeping the dust underneath the conveyors does not resolve the housekeeping task nor does it address the hazard of the grain dust. This decision choice was included to examine how workers would respond when a manager or supervisor directs that they skip a safety-related practice.

In the inadequate maintenance scenario workers were asked to make a decision choice after noticing that a section of the belt is worn, but the colleague believes that replacing the belt can wait as nothing has happened and the bucket elevator was running just fine. Workers were asked to select one of the following decision choices: 1) repair the belt: repairing the worn section of the belt cannot wait; 2) follow the colleague's advice: no belt repair needed; 3) the belt is still in one piece, and it will be okay to replace later; 4) talk to the colleague about repairing the belt.

A safety-oriented decision choice would be to repair the belt because a worn belt could become a potential ignition source for grain dust explosions by belt slippage where a conveyor belt starts to slip on the pully causing friction. Both training programs addressed common ignition sources found in the grain handling and processing industry and belt slippage was identified as one those sources. Repairing the belt may have negative implications on productivity because repairing the belt takes time. However, in this case, the safety concern about inadequate maintenance of grain handling equipment which could increase the likelihood of hazards from ignition sources from malfunctioning equipment was addressed.

Decision choices that were non-safety-oriented include: 1) talking to your colleague about repairing the belt; 2) the belt is still in one piece, you think it will be okay until you replace it later; 3) following the colleague's advice. Talking to your colleague about repairing the belt, while a safe intention, may cause conflict with your colleague, who wanted to wait to repair the belt. Furthermore, the decision choice does not specify that the worker actually fixed the belt. In this case, the safety concern about inadequate maintenance was not addressed.

The next decision choice focused on replacing the belt later because the belt was still in one piece. This decision choice was a non-safety-oriented choice because delaying a known safety issue (a potential ignition source) until later is not a safe action. This choice was included to examine the worker's attitude about safety. Failing to address safety hazards is indicative of a low level of safety culture. Further, allowing peers to convince workers to not address a safety hazard is also not a characteristic of a strong safety climate. Whenever safety issues are ignored, workers will conclude a low priority for safety, resulting in weak climate perceptions (Zohar, 2000).

Survey Implementation and Data Analysis

Two groups formed the population of this study. The first group included grain handling and processing professionals who had taken an online distance learning course on grain dust explosion mitigation (GEAPS 544) offered by the Grain Elevator Processing Society (GEAPS). The second group in the population included grain elevator employees from the upper Midwest who had completed a face-to-face grain dust explosion prevention training offered by Iowa State University and Purdue University personnel since 2015. Online training contacts were provided by GEAPS and face-to-face training contacts were provided by Iowa State University and Purdue University personnel. Of the population, a total of 177 individuals completed training online and 221 completed training face-to-face. Not all trainees had email addresses, and this limited the number of trainees that could complete the simulation and survey. Five online trainees had no valid email address, while 172 online trainees had a valid email address. Seventy-one face-to-face trainees had no valid email address, while 150 face-to-face trainees had email addresses. Online and face-to-face training contacts were cross-checked using the 2016 GEAPS directory.

Low response rates in web-based surveys are a primary concern to survey researchers (Fan & Yan, 2010). To increase response rates, the survey was administered using the Dillman, Smyth, and Christian (2009) approach. First, a preliminary email was sent on November 29, 2017 informing all potential respondents who had taken an online or face-to-face training on grain dust explosion prevention of an upcoming survey. The preliminary email helped identify active and inactive emails. Thirty-four (20%) online training contacts and 28 (19%) face-to-face training contacts were found to be inactive while 138 online and 122 face-to-face training contacts were active. An email with the survey link was sent to all active potential respondents in early December 2017. Reminders to take the survey were sent to all potential respondents with an active email with the first reminder sent on December 18, 2017 and the second reminder on January 2, 2018. In addition, potential respondents were informed how their responses would benefit the study and contact information of investigators were provided in all communications. Respondents were allowed to take the survey once. On January 5, 2018, the survey closed.

Of the 138 online training contacts, 31 responded. Of these, 23 provided usable data with a response rate of 17%. Of the 122 face-to-face training contacts, 47 responded. Of these 47, 43 provided usable data with a response rate of 35%. The total response rate of the online and face-to-face group was 25%. No personal identifiers were linked to the data and this limited follow-up options to increase the survey response rate. Data collected from the survey were analyzed using JMP (Pro version 13.1). Descriptive and inferential statistics were calculated.

A Fisher's exact test was used to test whether the decision choices made by workers and the information workers used to make decision choices were associated with the type of training and workers' level of perceived training effectiveness. This test is frequently used when sample sizes are small is more precise that the Chi-square test (Connelly, 2016). The Fisher's exact test measures whether proportions of one variable differ among the values of the other variable (McDonald, 2014). In other words, how likely were decision choices made by workers and the information workers used to make decision choices independent on the type of training they received and their level of perceived training effectiveness? This is important because training plays an essential role in educating workers how to work safely. Themes were created from the comments made by workers to the question of whether they had done anything different after taking the training provided at the end of the survey to examine behavioral changes. Other descriptive data analysis included the distribution of frequency of workers' responses to how useful the grain dust explosion prevention training was, frequency of workers decision choices and the information workers used to make decision choices.

CHAPTER 4. RESULTS AND DISCUSSION

Demographics

Online and face-to-face training participants were asked about their gender, age, and education level. Demographic results are shown in table 3. The sample consisted of 43 face-to-face training participants and 23 online training participants, for a total sample size of 66. Of the total sample size, 58 trainees were males and 8 were females. The participant ages ranged from 21-30 to over 60, with the most common response being 51-60 years of age. Participant education levels ranged from a bachelor's degree to a graduate degree with the most common response being a bachelor's degree.

Table 3. Demographic information of online and face-to-face training participants

		n	% of total
Training Participants	Face-to-face	43	65%
	Online	23	35%
Gender	Male	58	88%
	Female	8	12%
Age	Under 21	0	0%
	21-30	7	11%
	31-40	15	23%
	41-50	14	22%
	51-60	17	26%
	Over 60	12	18%
Education	Bachelor's degree	25	38%
	High school diploma	21	32%
	Associate degree	12	18%
	Graduate degree	8	12%

Decision Choice

Participants were presented four hypothetical decision-making scenarios that could realistically occur in a grain facility. For each scenario, decision choices were provided for selection. The first scenario focused on housekeeping, where respondents were asked how they would address an area that needed housekeeping. Figure 2 displays the distribution of decision choices made in the housekeeping scenario by respondents who have completed an online or face-to-face training.

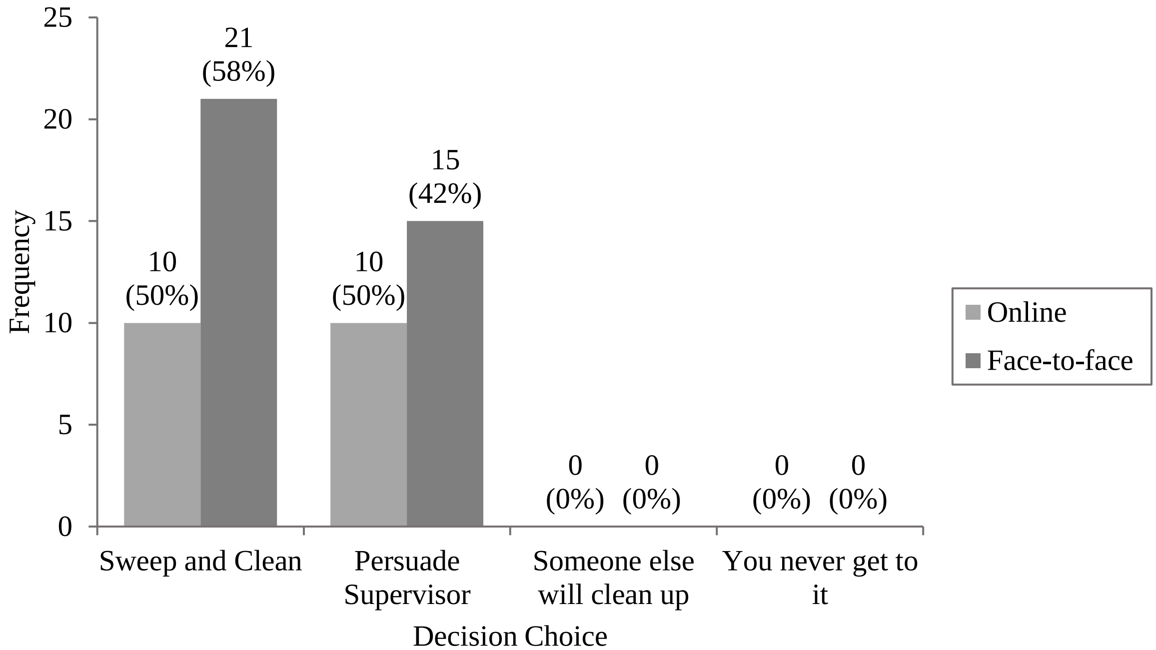

Figure 2. Distribution of frequency of decision choices made in the housekeeping scenario by respondents who took and online or face-to-face training in preventing grain dust explosions

The numbers and percentages above each bar in the graph represent the frequency and proportion of participants who selected that decision choice. Respondents selected only two of the four decision choices: sweep and clean and persuade the supervisor. Among the decision choices, sweep and clean was the most popular decision choice made by workers in the face-to-face training, whereas sweep and clean and persuade the supervisor were both popular decision choices made by workers in the online training. No responses for someone else will clean up and you never get to it were provided by workers in either training group.

Sweep and clean is a safety-oriented decision choice from a safety perspective because taking time immediately to sweep and clean the headhouse floor and equipment can help prevent grain dust explosions by reducing the presence of dust. Persuading the supervisor to allocate time later to finish housekeeping tasks is a non-safety-oriented decision choice because while it is a safe individual choice, contradicting the supervisor's opinion that housekeeping can be delayed could have negative implications for the worker. However, this decision choice is safer than assuming someone else would clean up the dust or promising to complete housekeeping tasks before the end of the day, but never getting to it. The fact that both training groups were able to make safe decision choices related housekeeping suggests that this audience may already have a higher engagement in housekeeping at their workplace. The safety content addressed in both the online and face-to-face training could also have influenced workers' safe decision choices regarding housekeeping. The topic on housekeeping was emphasized in both training programs.

The second scenario examined maintenance, where respondents were asked how they would respond if a sensor alarm went off. Figure 3 displays the distribution of decision choices made in the maintenance scenario by respondents who have taken an online or face-to-face training in preventing grain dust explosions. The numbers and percentages above each bar in the graph represent the frequency and proportion of participants who selected that decision choice. As with the first scenario, respondents selected only two of the four decision choices: take precautions and prevention of future alarms. Among these decision choices, taking precautions by running the bucket elevator empty was the most popular decision choice with both training groups. The remaining respondents chose prevention of future alarms. No responses on following the colleague's advice and treating the alarm as false were provided by workers in either training groups.

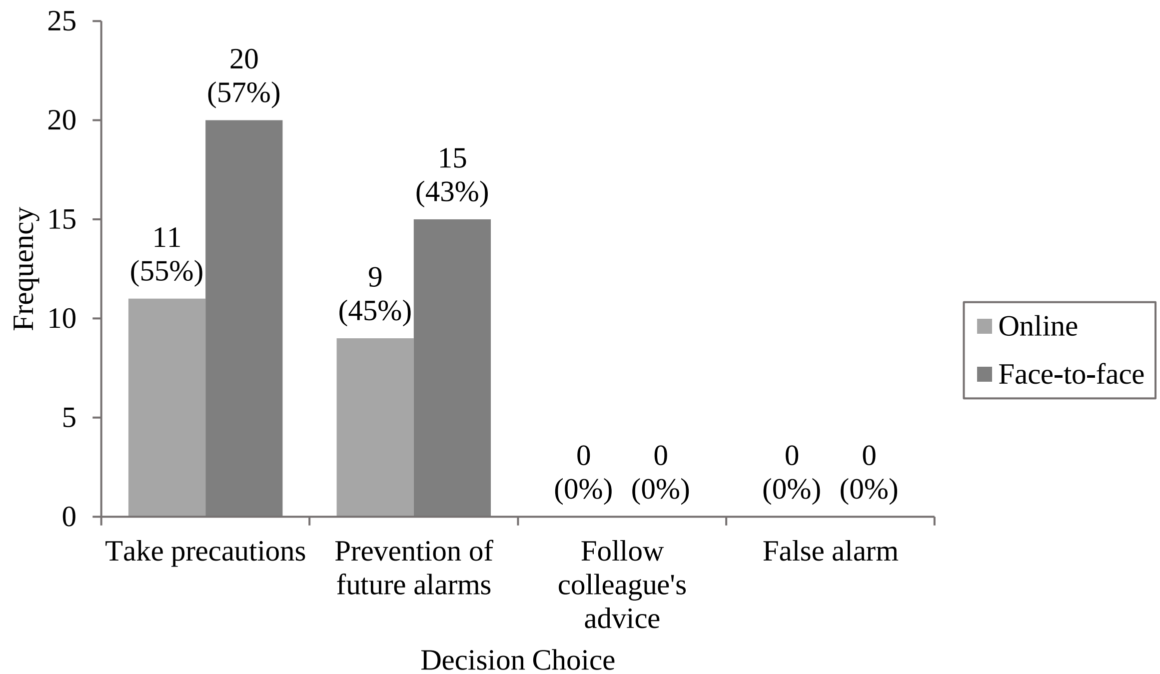

Figure 3. Distribution of frequency of decision choices made in the maintenance scenario by respondents who have completed an online or face-to-face training in preventing grain dust explosions

Taking precautions is a safety-oriented response because the purpose of a sensor alarm is to provide an indicator of a safety hazard. Preventing future alarms is a non-safety-oriented response because while it has safe individual intentions, stopping the bucket elevator after every alarm would be too cautious and the amount work completed would be limited if the process were to be stopped after every alarm. However, this decision choice is safer than following the colleague's advice of keeping the bucket elevators running or treating the alarm as false. The fact that both training groups were able to make safe decision choices concerning maintenance suggests that this audience may already have a higher engagement in performing equipment maintenance at their workplace. The safety content addressed in both the online and face-to-face training could also have determined the workers' safe decision choices concerning maintenance. The topic on equipment maintenance was covered in both the online and face-to-face training.

The next two scenarios focused on safety shortcuts. Shortcut opportunities occur frequently in grain operations (Walker, 2010; Mosher et al., 2013) and the scenarios were created to examine how individuals would respond to shortcut opportunities involving grain dust hazards. The first shortcut scenario involved taking shortcuts in housekeeping, where respondents were asked how they would respond if their supervisor told them to sweep the dust underneath the conveyors temporarily. Figure 4 displays the distribution of decision choices made in the housekeeping shortcut scenario by both training groups.

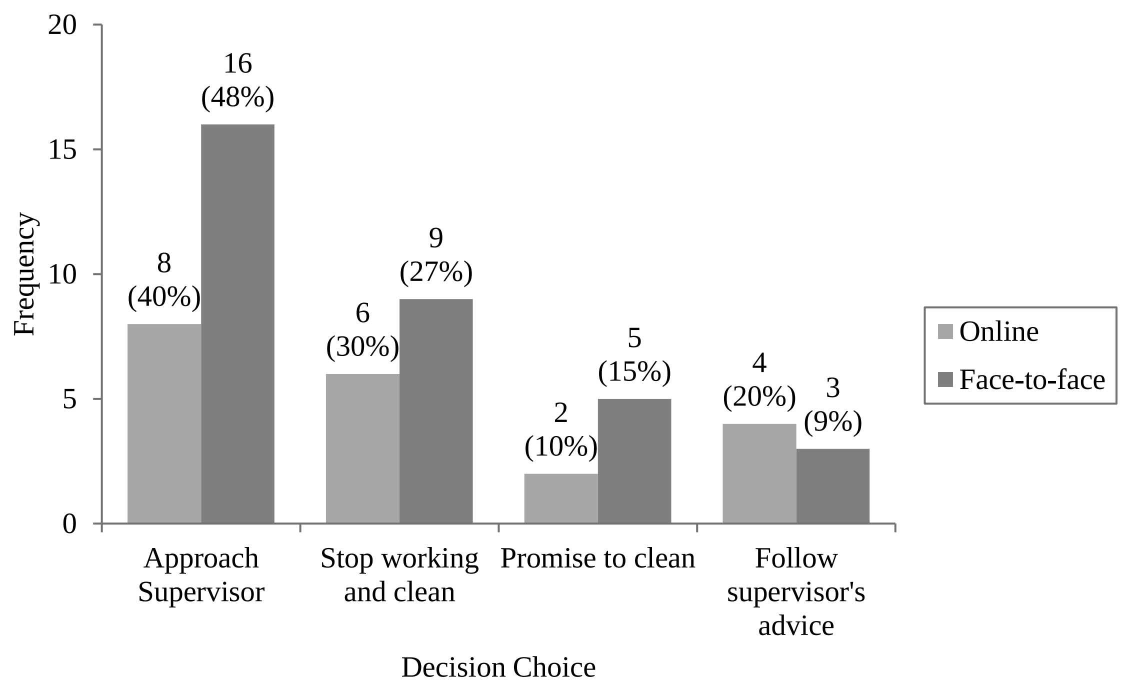

Figure 4. Distribution of frequency of decision choices made in the housekeeping shortcut scenario by respondents who took and online or face-to-face training in preventing grain dust explosions

The numbers and percentages above each bar in the graph signify the frequency and proportion of participants who selected that decision choice. Respondents selected all four decision choices: approach the supervisor, stop working and clean, promise to clean, and follow the supervisor's advice. Among the decision choices, approaching the supervisor was the most popular decision choice made by workers in both the online and face-to-face training groups. The remaining respondents either chose to stop working and take time to clean, promise to clean before the end of the day, or to follow the supervisor's advice of sweeping the dust underneath the conveyors.

Of the four decision choices presented in the housekeeping shortcut scenario, stop working and clean is a safety-oriented response because reducing the dust created by grain handling and processing can help prevent grain dust explosions. Approaching the supervisor, while a safe decision choice, may not encourage a positive relationship between the supervisor and worker. Promising to clean before the end of the day, while a safe individual choice, is a non-safety-oriented response because the housekeeping task was not actually completed. Following the advice from the supervisor, a non-safety-oriented response, because sweeping the dust underneath the conveyors does not complete the housekeeping task nor does it address grain dust hazards. The fact that any of the workers chose non-safety-oriented decision choices implies that further emphasis on the hazards of taking safety shortcuts are needed in both the online and face-to-face training. This is important because safety shortcut opportunities do not only occur frequently in grain operations but in all workplaces (Keren et al., 2009; Walker, 2010; and Mosher et al., 2014).

The second safety shortcut scenario focused on inadequate maintenance scenario of grain handling equipment, where respondents were asked how they would respond if their colleague told that replacing a worn section of a belt in a bucket elevator could wait. Figure 5 displays the distribution of decision choices made in the inadequate maintenance by respondents. The numbers and percentages above each bar represent the frequency and proportion of participants who selected that decision choice.

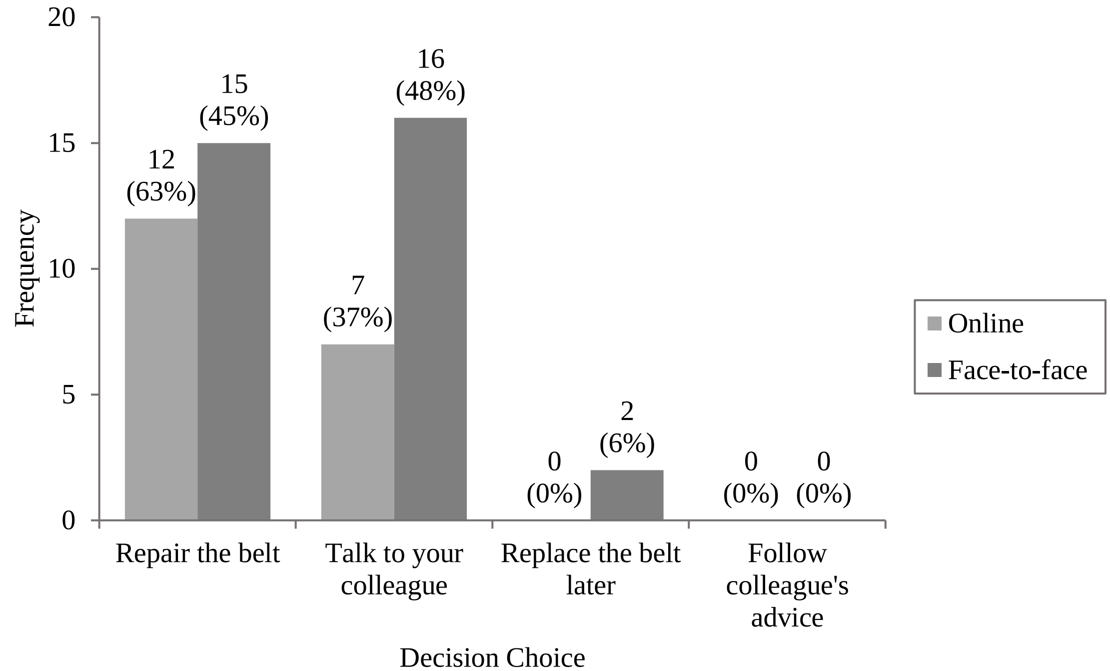

Figure 5. Distribution of frequency of decision choices made in the inadequate maintenance scenario by respondents who completed an online or face-to-face training in preventing grain dust explosions

With the exception of the decision choice (replace the belt later) made by respondents in the face-to-face group. Respondents selected two of the four decision choices: repair the belt and talk to the colleague. No responses on replace the belt later were provided by the online group and no responses on follow the colleague's advice were provided by either training groups.

Repair the belt is a safety-oriented response because a worn belt could lead to a potential ignition source for a grain dust explosion. Talking to the colleague is a non-safety-oriented decision choice because while it has safe individual intentions, contradicting the colleague's desire to wait to repair the belt may result in a conflict. However, this decision choice is safer than replacing the belt later because putting off a known issue (ignition source) until later is an unsafe action. Following the colleague's advice of not repairing the belt is not a safety-oriented response because it does not resolve the issue.

Similarly, with the decision choices made in the housekeeping shortcut scenario, the fact that any of the workers chose non-safety-oriented decision choice implies that further emphasis on the hazards of taking safety shortcuts are needed in both the online and face-to-face training.

Information Used

The second portion of the scenarios asked all participants to rank potential information used to make decision choices. Five pieces of information were provided for participants to rank in the housekeeping and maintenance scenarios and four pieces of information were provided for participants to rank in the housekeeping shortcut and inadequate maintenance scenarios. In the housekeeping and maintenance scenarios, participants ranked each piece of information from one to five with one being the most important information used to make their decision choice and five the least important information used to make a decision choice. In the housekeeping shortcut and inadequate maintenance scenarios, participants ranked each piece of information from one to four with one being the most important information used to make their decision choice and four being the least important information used to make a decision choice.

Figure 6 displays the distribution of information used by workers who have made a decision choice in the housekeeping scenario. The numbers and percentages above each bar in the graph signify the frequency and proportion of workers who used that information to make their decision choice. Among the information workers used to make their decision choices, safety concern was the most chosen piece used by the majority of workers. Supervisor response, low chance of safety issue, job responsibilities, and productivity were the least chosen pieces of information used by workers in making their decision choices.

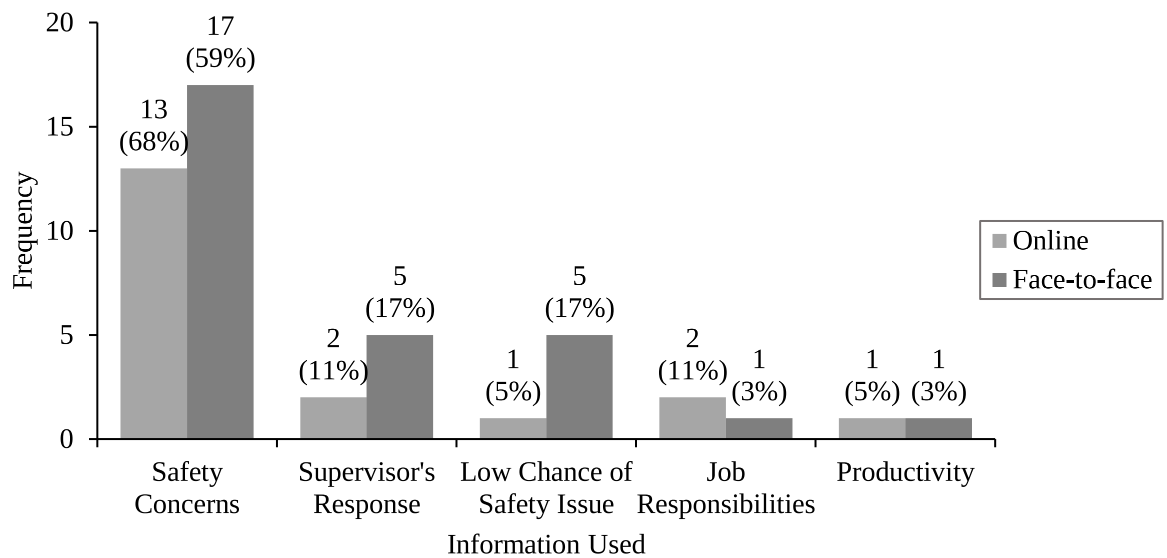

Figure 6. Distribution of frequency of information used in the housekeeping scenario to make a decision choice by respondents who have completed an online or face-to-face training in preventing grain dust explosions

Figure 7 displays the distribution of information used by workers who have made a decision choice in the maintenance scenario. The numbers and percentages above each bar represent the frequency and proportion of workers who used that information to make their decision choices. The information workers used to make their decision choice in the maintenance scenario included only two of the five pieces of information: safety concerns and indications of problem. The largest training group chose one of two pieces of information: safety concerns and indications of problem. No responses for productivity, peer pressure, and save time and money were provided by workers in either groups.

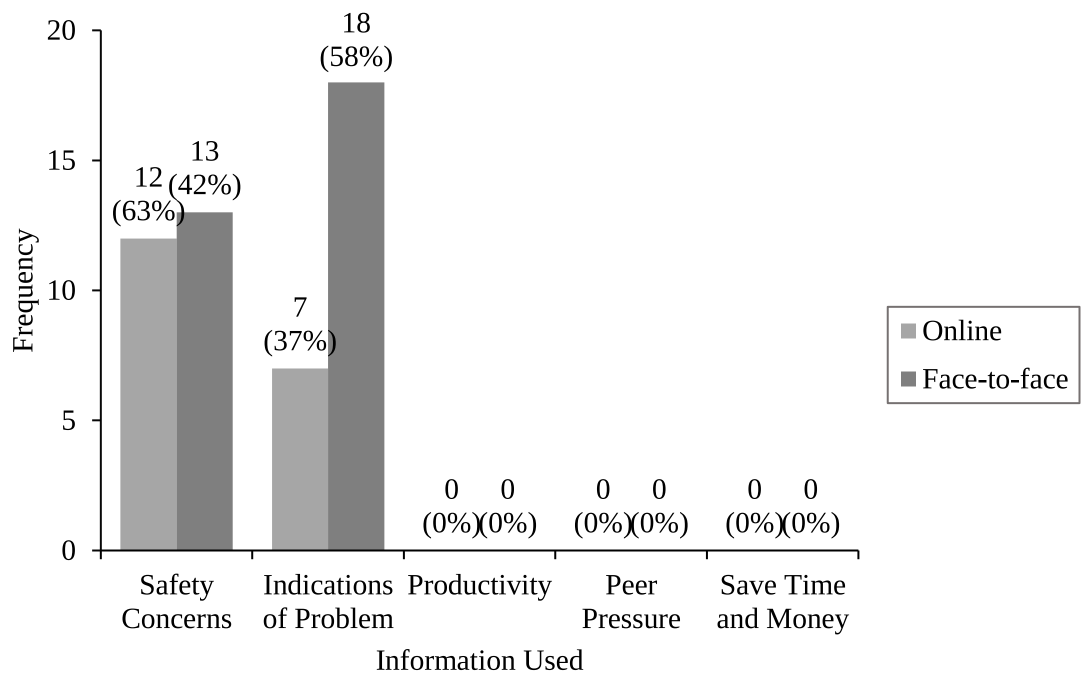

Figure 7. Distribution of frequency of information used in the maintenance scenario to make a decision choice by respondents who have completed an online or face-to-face training in preventing grain dust explosions

Figure 8 displays the distribution of information used by workers to make their decision choice in the housekeeping shortcut scenario. The numbers and percentages above each bar in the graph represent the frequency and proportion of workers who used that information to make their decision choices. The information workers used to make their decision choice in the housekeeping shortcut scenario included only two of the four pieces of information: safety concerns and supervisor response. Safety concerns were the most chosen piece of information used by the majority of workers. Supervisor response was the least chosen piece of information used by workers in their decision-making choice. No responses for priority of work tasks and productivity were provided by workers in either training groups.

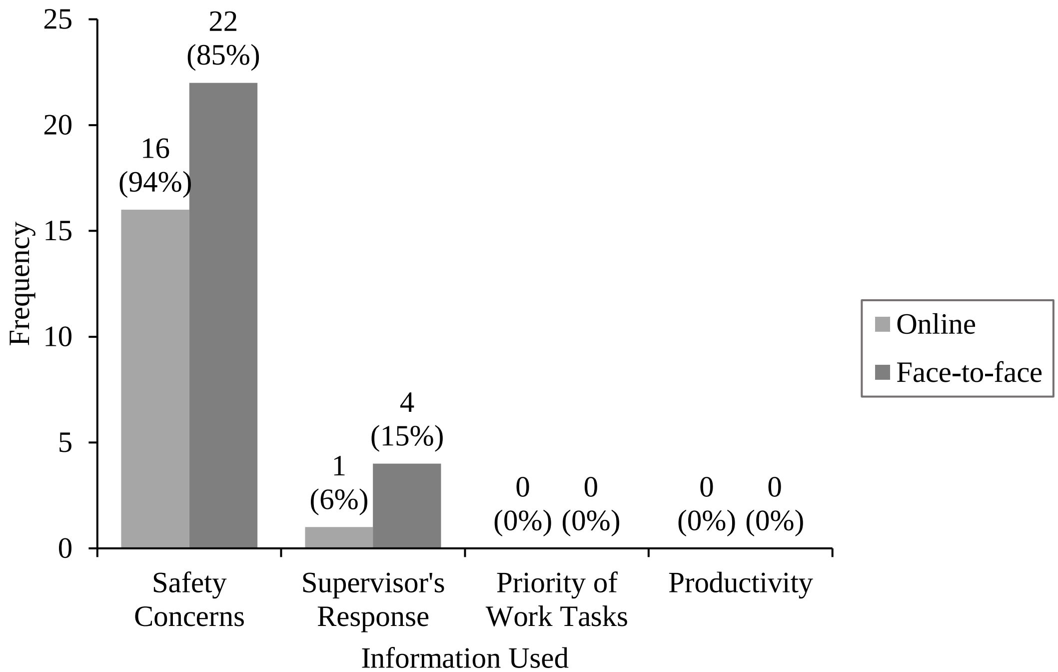

Figure 8. Distribution of frequency of information used in the housekeeping shortcut scenario to make a decision choice by respondents who have completed an online or face-to-face training in preventing grain dust explosions

Figure 9 displays the distribution of information used by workers who have made a decision choice in the inadequate maintenance scenario. The numbers and percentages above each bar represent the frequency and proportion of workers who used that information to make their decision choice. The information workers used to make their decision choice in the inadequate maintenance scenario included only three of the four pieces of information: safety concerns, peer pressure, and productivity. Safety concern was the most chosen piece of information used by the majority of workers. Peer pressure and productivity were the least chosen pieces of information used by workers in making their decision choices. No responses for save time and money was provided by workers in either training groups.

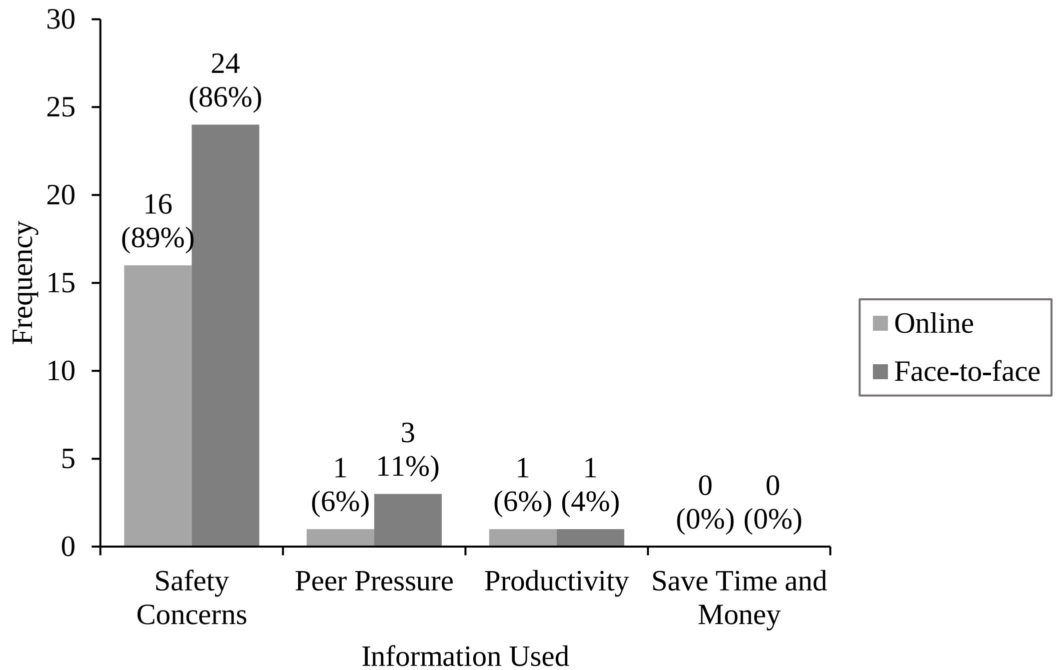

Figure 9. Distribution of frequency of information used in the inadequate maintenance scenario to make a decision choice by respondents who have completed an online or face-to-face training in preventing grain dust explosions

In this study, findings suggest that safety concerns were an important part of decision-making patterns for grain industry professionals addressing safety-specific scenarios related to grain dust explosion prevention. This finding aligns with Mosher et al. (2014), where safety concerns were also an important part of decision-making. One reason for this outcome could be that the contents addressed in both the online and face-to-face training influenced this audience to have a safety concern for grain dust explosions. The fact that this audience also worked in a hazardous environment suggests that this audience was aware of the hazards in the grain handling and processing industry (Walker, 2010) and given this circumstance, have a safety concern for grain dust explosions.

Indication of a problem that could lead to a grain dust explosion, was found to be an important part of decision-making patterns for employees in this study. The fact that this audience was able to indicate an issue concerning the bearing temperature alarm and complete the decision-making task safely suggests that this audience recognized the importance and purpose of bearing temperature sensors. One reason for this outcome could be that the contents addressed in both the online and face-to-face training, specifically on taking precautionary measures may have played a role on this information the audience used to make their decision choice.

The lack of significant emphasis on the supervisor response was unexpected in this study. This finding contradicts Mullen (2004), where supervisor actions were found to directly influence workers perceived safety climate, meaning if supervisors were committed to safety, then it was more likely for workers to the same. The fact that this audience was able to disregard the supervisor's opinion and complete the decision-making task safely implies that this audience prioritized safety more importantly than their supervisor's opinion. One reason for this outcome could be that the contents addressed in both the online and face-to-face training encouraged workers to make preventing grain dust explosions a priority at their workplace.

Low chance of safety issue in this study was not found to be an important part of decision-making patterns for grain industry professionals addressing safety-specific scenarios related to grain dust explosion prevention. This finding aligns with previous research where perceived risk was found to be associated with workers' willingness to adopt safe practices (Mullen, 2004). The fact that workers were able to perceive grain dust hazards highly and complete the decision-making simulation safely suggests that this audience had a positive safety attitude towards preventing grain dust explosions.

Job responsibilities in this study were not found to be an important part of decision-making patterns for grain industry professionals addressing safety-specific scenario related to grain dust explosion prevention. This finding contradicts a phenomenon known in the literature as social-loafing, where individuals exert less effort on a job when working in a group, assuming others would pick up parts of the job (Jassawalla, Sashittal, & Malashe, 2009). The fact that this audience was able to complete tasks related to preventing grain dust explosions, even when the tasks may not have been their primary responsibility suggests this audience may have been aware of the consequences of a grain dust explosions.

Productivity in this study was not found to be an important part of decision-making patterns for grain industry professionals addressing safety-specific scenarios related to grain dust explosion prevention. Mullen (2004) noted that productivity was one of the fundamental factors that explained unsafe practices. However, that was not the case in this study. One reason for this outcome may be related to the Prospect Theory, where this audience might have acknowledged that there was little to gain from risk-seeking (Tversky & Wakker, 1995). A second theoretical basis might be that this audience experienced previous regrets, thus creating an anticipation of regrets, influencing them to make safer decision choices (Zeelenberg, 1999).

Peer pressure was not found to be a significant factor at influencing workers decision-making choices. This finding contradicts the findings of Keren et al. (2009), where peer pressure was found to be a significant factor in workers' decision-making choices. One reason for this outcome could be that supervisors were committed to safety, inducing workers to be committed to safety as well (Mullen, 2004). Further, a positive peer pressure at the worker's facility may have influenced workers to work safely. The peer pressure in Keren's et al. (2009) study was established as a negative influence, as it was in this study as well.

Priority of work tasks in this study was not found to be an important part of decision-making patterns for grain industry professionals addressing safety specific scenarios. This finding implies that workers were able to get to preventive activities related to grain dust explosions regardless the number of priorities. The fact that workers were able to do this suggests that this audience may have already established a safety program, where preventive activities related to grain dust explosions are carried out consistently on a daily basis.

Saving time and money in this study was not found to be an important part of decision-making patterns for grain industry professionals addressing safety-specific scenarios. This finding implies that workers were willing to spend the money and time to repair the smallest issues related to maintenance. The reason for this could be related to workers' knowledge and awareness of grain dust hazards learned from the training, where the lack of maintenance could become a potential ignition source for a grain dust explosion.

Training Usefulness Responses

Once trainees completed the decision-making simulation, they completed the training usefulness questions. These questions were included in the survey to ask online and face-to-face trainees how useful the training was for them and how often they used the information learned in the training sessions in their daily tasks. The purpose of these questions was to measure workers' perception of training usefulness. This is important because training is a critical component of worker safety. The frequency of workers' responses to the questions are presented in table 4.

Table 4. Frequency of workers' response to training usefulness questions

Training Usefulness Questions		Frequency	% of total
To what extent did you use your grain dust explosion prevention training in answering the scenarios?	25%	1	1%
	50%	10	19%
	75%	17	33%
	100%	24	46%
Was the training helpful?	Strongly agree	21	40%
	Agree	28	53%
	Neutral	4	8%
	Disagree	0	0%
	Strongly disagree	0	0%
How would you rank grain dust in terms of its safety hazard?	High	49	94%
	Moderate	3	6%
	Low	0	0%
	None	0	0%
How much control do you have now on mitigating grain dust explosions?	High	32	62%
	Moderate	15	29%
	Low	2	4%
	None	3	6%

The first question addressed the extent of grain dust explosion prevention training used in answering the decision-making scenarios. Workers’ responses were measured on a scale from 25 percent to 100 percent. Twenty-five percent represent that some extent of the grain dust explosion prevention training was used in answering the scenarios. One hundred percent represent that the full extent of the training was used in answering the scenarios. The responses ranged from 25 percent to 100 percent, with the most common response being 100%. This finding suggests that the majority of workers used the training to answer the decision-making scenarios. The fact that most workers were able to use the training to answer the scenarios implies that workers found the training contents addressed in both the online and face-to-face training useful and applicable to realistic situations.

The second question asked whether the training was helpful. Workers' responses were measured on a scale from strongly agree to strongly disagree. Strongly agree represent that the training was helpful. Strongly disagree represent that the training was not helpful. The responses ranged from strongly agree to neutral, with the majority of workers responding that the training was helpful. This finding implies that both the online and face-to-face training in preventing grain dust explosions were helpful.

The third question asked workers to rank grain dust in terms of its safety hazard. Workers' responses were measured on a scale from high to none. High represent that grain dust was a safety hazard and none represent that grain dust was a not a safety hazard. The majority of workers responded strongly that grain dust was indeed a safety hazard. This finding implies that workers were more aware of grain dust hazards after taking the training. The fact that this audience was more aware of grain dust hazards after taking the training suggests that the training contents addressed in both the online and face-to-face training were appropriate.

The fourth question addressed the level of control on mitigating grain dust explosions. Workers' responses were measured on a scale from high to none. High represent that workers had a higher control on mitigating grain dust explosions. None, represent that workers had no control on mitigating grain dust explosions. Responses ranged from high to none, with the most common response being high. This finding suggests that workers had a higher control on mitigating grain dust explosions after taking the training. The fact that this audience had a higher control on mitigating grain dust explosions implies that the training contents addressed in both training approaches positively influenced workers to focus on mitigating grain dust explosions. While the majority of workers found the grain dust explosion prevention training to be useful. The fact that any of the workers who found the training to not be useful implies that continuous improvement of the training is needed.

Implications for Open-ended Comments

At the end of the survey, participants were asked whether they have done anything different at the workplace after taking an online or face-to-face grain dust explosion prevention training. These actions represent behavioral change resulting from the training and provide evidence of Level 4 learning (Kirkpatrick, 2009). Twenty usable comments were provided by participants including workers who responded that they had not done anything different at the workplace after taking the training. Of the twenty, the majority of workers responded that they had done something different at their workplace.

Themes were created from the comments made by workers. These themes included *housekeeping*, *dust collecting systems*, *precautionary measures*, and *no action taken*. The importance of housekeeping was emphasized in the majority of workers comments, such as making housekeeping a priority or improving the facility's housekeeping program to help limit the accumulation of dust. There were workers who took the action of installing dust collection systems or reviewing the location of their dust system to determine its effectiveness. Precautionary measures were also taken by workers. These measures include reviewing existing safety procedure and conducting daily walk-throughs of the facility, looking for areas that need housekeeping or equipment maintenance. Other workers commented that they have not had the chance to apply their newly learned knowledge and skills acquired from the grain dust training.

Several conclusions can be drawn from the open-ended comments provided by workers. First, the comments made by workers relating to housekeeping, dust collecting systems, and taking precautionary measures to prevent grain dust explosions were safety-oriented actions or best practices that were covered in the online and face-to-face training. This suggests that both formats of training were effective in conveying the information that participants needed to perform safely on the job. Second, safety-oriented comments made by workers suggest that workers were able to apply newly learned knowledge and or skill at the workplace as a result of training. This is important because it can help trainers determine the overall impact of training and whether learning took place. Third, safety-oriented comments made by workers suggest that workers were more aware of the hazards of grain dust explosions as a result of training, enabling them to take more of a proactive stance towards preventing grain dust explosions. Although the majority of workers were able to apply newly learned behavior related to preventing grain dust explosions at the workplace, it does not mean they were able to apply their newly learned behavior consistently. Therefore, further evaluation on behavioral change resulting from training is needed to determine the impacts of training overall.

Analysis of Association

To answer the first research question of whether the format of grain dust explosion prevention training influenced workers' safety-oriented decision-making choice, the Fisher's exact test was performed to measure the likelihood of an association between workers' safety-oriented decision-making choice in the four scenarios and the format of training. Data for each scenario will be presented separately. Table 5 presents the results of the likelihood of an association between the format of training and the decision choice made by workers in the housekeeping scenario.

Table 5. Results of the likelihood of an association between the format of training and the decision choice made by workers in the housekeeping scenario

Housekeeping Scenario			
	Training Format		
Decision Choice	Face-to-face	Online	Total
Persuade supervisor	15	10	25
Sweep and clean	21	10	31
Someone else will clean up	0	0	0
You never get to it	0	0	0
Total	36	20	56

Statistic	P-value
Fisher's Exact Test	0.5855

The Fisher exact test was used to test if the null hypothesis (that the decision choice made by workers and the format of training was not associated in the housekeeping scenario) was true. A small p-value (below 0.05) would indicate strong evidence to reject the null hypothesis while a large p-value (above 0.05) would indicate weak evidence, resulting in a failure to reject the null hypothesis. Results from the analysis failed to reject the null hypothesis (p-value>0.05), indicating that no significant association was observed between the decision choice workers have chosen in the housekeeping scenario and the format of training. This finding suggests that the decision choice made by workers in the housekeeping scenario was not influenced by the format of training.

Table 6 presents the result of the likelihood of an association between the format of training and the decision choice made by workers in the maintenance scenario. The Fisher's exact test was used to test if the null hypothesis (that the decision choice made by workers and the format of training were not associated in the maintenance scenario) was true.

Table 6. Results of the likelihood of an association between the format of training and the decision choice made by workers in the maintenance scenario

Maintenance Scenario			
	Training Format		
Decision Choice	Face-to-face	Online	Total
Take precautions	20	11	31
Prevention of future alarms	15	9	24
Follow colleague's advice	0	0	0
False alarm	0	0	0
Total	35	20	55

Statistic	P-value
Fisher's Exact Test	0.9999

Results from the analysis failed to reject the null hypothesis (p-value>0.05), signifying that no significant association was observed between the decision choices workers have selected in the maintenance scenario and the format of training. This finding suggests that the decision choice made by workers in the maintenance scenario was not influenced by the format of training.

Table 7 presents the result of the likelihood of an association between the format of training and the decision choice made by workers in the housekeeping shortcut scenario. The Fisher's exact test was used to test if the null hypothesis (that the decision choice made by workers and the format of training were not associated in the housekeeping shortcut scenario) was true.

Results from the analysis failed to reject the null hypothesis (p-value>0.05), indicating that no significant association was observed between the decision choice workers have made in the housekeeping shortcut scenario and the format of training. This finding suggests that the decision choice made by workers in the housekeeping shortcut scenario was not influenced by the format of training.

Table 7. Results of the likelihood of an association between the format of training and the decision choice made by workers in the housekeeping shortcut scenario

Housekeeping Shortcut Scenario			
	Training Format		
Decision Choice	Face-to-face	Online	Total
Approach supervisor	16	8	24
Stop working and clean	9	6	15
Promise to clean	5	2	7
Follow supervisor's advice	3	4	7
Total	33	20	53

Statistic	P-value
Fisher's Exact Test	0.7150

Table 8 shows the result of the likelihood of an association between the format of training and the decision choice made by workers in the inadequate maintenance scenario. The Fisher's exact test was used to test if the null hypothesis (that the decision choice made by workers and the format of training were not associated in the inadequate maintenance scenario) was true.

Table 8. Results of the likelihood of an association between the format of training and the decision choice made by workers in the inadequate maintenance scenario

Inadequate Maintenance Scenario			
	Training Format		
Decision Choice	Face-to-face	Online	Total
Repair the belt	15	12	27
Talk to your colleague	16	7	23
Replace the belt later	2	0	2
Follow colleague's advice	0	0	0
Total	33	19	52

Statistic	P-value
Fisher's Exact Test	0.3969

Results from the analysis failed to reject the null hypothesis (p-value>0.05), indicating that no significant association was observed between the decision choice workers have made in the inadequate maintenance scenario and the format of training. This finding suggests that the decision choice made by workers in the inadequate maintenance scenario was not influenced by the format of training.

To answer the second question of whether the format of grain dust explosion prevention training influenced the information people who work with grain dust hazards use to make a safety-oriented decision-making choice, the Fisher's exact test was carried out to measure the likelihood of an association between the information workers used to make a decision choice and the format of training for all four scenarios.

The Fisher's exact test was used to test if the null hypothesis (that the information workers used to make a decision choice and the format of training were not associated) was true. Results of the likelihood of an association between the format of training and the information workers used to make a safety-oriented choice in the housekeeping scenario are shown in table 9.

Table 9. Results of the likelihood of an association between the format of training and information workers used to make a decision choice in the housekeeping scenario

Housekeeping Scenario			
	Training Format		
Information Used	Face-to-face	Online	Total
Safety concerns	17	13	30
Supervisor's response	5	2	7
Low chance of safety issue	5	1	6
Job responsibilities	1	2	3
Productivity	1	1	2
Total	29	19	48

Statistic	P-value
Fisher's Exact Test	0.5831

Results from the analysis failed to reject the null hypothesis (p-value>0.05), signifying that no significant association was observed between the information workers have used to make a decision choice in the housekeeping scenario and the format of training. This finding suggests that the information workers used to make a decision choice in the housekeeping scenario was not influenced by the format of training.

Table 10 presents the results of the likelihood of an association between the format of training and the information workers used to make a safety-oriented decision-making choice in the maintenance scenario. The Fisher's exact test was used to test if the null hypothesis (that the information workers used to make a safety-oriented decision-making choice and the format of training were not associated) was true.

Table 10. Results of the likelihood of an association between the format of training and the information workers used to make a decision choice in the maintenance scenario

Maintenance Scenario			
	Training Format		
Information Used	Face-to-face	Online	Total
Safety concerns	13	12	25
Indications of problem	18	7	25
Peer pressure	0	0	0
Productivity	0	0	0
Save time and money	0	0	0
Total	31	19	50

Statistic	P-value
Fisher's Exact Test	0.2436

Results from the analysis failed to reject the null hypothesis (p-value>0.05), indicating that no significant association was observed between the information workers have used to make a decision choice in the maintenance scenario and the format of training. This finding suggests that the information workers used to make a safety-oriented decision-making choice was not influenced by the type of training.

Table 11 shows the results of the likelihood of an association between the format of training and the information workers used to make a decision choice in the housekeeping shortcut scenario. The Fisher's exact test was used to test if the null hypothesis (that the information workers used to make a decision choice and the format of training were not associated) was true.

Results from the analysis failed to reject the null hypothesis (p-value>0.05), indicating that no significant association was observed between the information workers have used to make a safety-oriented decision-making choice in the housekeeping shortcut scenario and the format of training. This finding suggests that the information workers used to make a safety-oriented choice in the housekeeping shortcut scenario was not influenced by the type of training.

Table 11. Results of the likelihood of an association between the format of training and the information workers used to make a decision choice in the housekeeping shortcut scenario

Housekeeping Shortcut Scenario			
	Training Format		
Information Used	Face-to-face	Online	Total
Safety concerns	22	16	38
Supervisor's response	4	1	5
Priority of work tasks	0	0	0
Productivity	0	0	0
Total	26	17	43

Statistic	P-value
Fisher's Exact Test	0.6327

Table 12 presents the results of the likelihood of an association between the format of training and the information workers used to make a safety-oriented decision-making choice in the inadequate maintenance scenario. The Fisher's exact test was used to test if the null hypothesis (that the information workers used to make a safety-oriented decision-making choice and the format of training were not associated) was true.

Results from the analysis failed to reject the null hypothesis (p-value>0.05), indicating that no significant association was observed between the information workers have used to make a safety-oriented decision-making choice in the inadequate maintenance scenario and the format of training. This finding suggests that the information workers used to make a safety-oriented decision-making choice in the inadequate maintenance scenario was not influenced by the type of training.

Table 12. Results of the likelihood of an association between the format of training and the information workers used to make a decision choice in inadequate maintenance scenario

Inadequate Maintenance Scenario			
	Training Format		
Information Used	Face-to-face	Online	Total
Safety concerns	24	16	40
Peer pressure	3	1	4
Productivity	1	1	2
Save time and money	0	0	0
Total	28	18	46

Statistic	P-value
Fisher's Exact Test	0.9999

To answer the third question of whether the level of perceived training effectiveness determined the decision choices people who work with grain dust hazards make, the Fisher's exact test was performed to measure the likelihood of an association between workers' decision-making choice in the four scenarios and the helpfulness of the training. Data for each scenario will be presented separately.

The Fisher's exact test was used to test if the null hypothesis (that the decision choice made by workers and the helpfulness of the training were not associated in the housekeeping scenario) was true. Results of the likelihood of an association between training helpfulness and the decision choice made by workers in the housekeeping scenario are shown in table 13.

Results from the analysis failed to reject the null hypothesis (p-value>0.05), indicating that no significant association was observed between the decision choice workers have chosen in the housekeeping scenario and the helpfulness of the training. This finding suggests that the decision choice made by workers in the housekeeping scenario was not influenced by whether the training was helpful.

Table 13. Results of the likelihood of an association between training helpfulness and the decision choice made by workers in the housekeeping scenario

Housekeeping Scenario				
	Training Helpfulness			
Decision Choice	Disagree	Neutral	Agree	Total
Persuade supervisor	0	3	20	23
Sweep and clean	0	0	29	29
Someone else will clean up	0	0	0	0
You never get to it	0	0	0	0
Total	0	3	49	52

Statistic	p-value
Fisher's Exact Test	0.0801

Table 14 presents the result of the likelihood of an association between training helpfulness and the decision choice made by workers in the maintenance scenario. The Fisher's exact test was used to test if the null hypothesis (that the decision choice made by workers and the perceived helpfulness of the training were not associated in the maintenance scenario) was true.

Table 14. Results of the likelihood of an association between training helpfulness and the decision choice made by workers in the maintenance scenario

Maintenance Scenario				
	Training Helpfulness			
Decision Choice	Disagree	Neutral	Agree	Total
Take precautions	0	3	25	28
Prevention of future alarms	0	0	24	24
Follow colleague's advice	0	0	0	0
False alarm	0	0	0	0
Total	0	3	49	52

Statistic	P-value
Fisher's Exact Test	0.2398

Results from the analysis failed to reject the null hypothesis (p-value>0.05), signifying that no significant association was observed between the decision choices workers have chosen in the maintenance scenario and the helpfulness of the training. This finding suggests that the decision choice made by workers in the maintenance scenario was not influenced by whether the training was perceived to be helpful.

Table 15 presents the result of the likelihood of an association between training helpfulness and the decision choice made by workers in the housekeeping shortcut scenario. The Fisher's exact test was used to test if the null hypothesis (that the decision choice made by workers and the helpfulness of the training were not associated in the housekeeping shortcut scenario) was true. Results from the analysis failed to reject the null hypothesis (p-value>0.05), indicating that no significant association was observed between the decision choices workers have selected in the housekeeping shortcut scenario and the helpfulness of the training. This finding suggests that the decision choice made by workers in the housekeeping shortcut scenario was not influenced by whether the training was perceived to be helpful.

Table 15. Results of the likelihood of an association between training helpfulness and the decision choice made by workers in the housekeeping shortcut scenario

Housekeeping Shortcut Scenario				
	Training Helpfulness			
Decision Choice	Disagree	Neutral	Agree	Total
Approach supervisor	0	3	21	24
Stop working and clean	0	0	15	15
Promise to clean	0	0	6	6
Follow supervisor's advice	0	0	7	7
Total	0	3	49	52

Statistic	P-value
Fisher's Exact Test	0.4869

Table 16 presents the result of the likelihood of an association between training helpfulness and the decision choice made by workers in the inadequate maintenance scenario. The Fisher's exact test was used to test if the null hypothesis (that the decision choice made by workers and the perceived helpfulness of the training were not associated in the inadequate maintenance scenario) was true.

Table 16. Results of the likelihood of an association between training helpfulness and the decision choice made by workers in the inadequate maintenance scenario

Inadequate Maintenance Scenario				
	Training Helpfulness			
Decision Choice	Disagree	Neutral	Agree	Total
Repair the belt	0	1	26	27
Talk to your colleague	0	1	21	22
Replace the belt later	0	0	2	2
Follow colleague's advice	0	0	0	0
Total	0	2	49	51

Statistic	P-value
Fisher's Exact Test	0.9999

Results from the analysis failed to reject the null hypothesis (p-value>0.05), indicating that no significant association was observed between the decision choices workers have selected in the housekeeping shortcut scenario and the helpfulness of the training. This finding suggests that the decision choice made by workers in the inadequate maintenance scenario was not influenced by whether the training was helpful.

To answer the fourth question of whether the level of perceived training effectiveness determined the information people who work with grain dust hazards use to make decision choices, the Fisher's exact test was carried out to measure the likelihood of an association between the information workers used to make a decision choice in the four scenarios and the helpfulness of the training.

The Fisher's exact test was used to test if the null hypothesis (that the information workers used to make a decision choice and the helpfulness of the training were not associated in the housekeeping scenario) was true. Results of the likelihood of an association between training helpfulness and the information workers used to make a decision choice in the housekeeping scenario is presented in table 17.

Table 17. Results of the likelihood of an association between training helpfulness and the information workers used to make a decision choice in the housekeeping scenario

Housekeeping Scenario				
	Training Helpfulness			
Information Used	Disagree	Neutral	Agree	Total
Safety concerns	0	0	28	28
Supervisor's response	0	0	6	6
Low chance of safety issue	0	0	6	6
Job responsibilities	0	1	2	3
Productivity	0	0	1	1
Total	0	1	43	44

Statistic	P-value
Fisher's Exact Test	0.0909

Results from the analysis failed to reject the null hypothesis (p-value>0.05), signifying that no significant association was observed between the information workers have used to make a decision choice in the housekeeping scenario and the perceived helpfulness of the training. This finding suggests that the information workers used to make a decision choice in the housekeeping scenario was not influenced by whether the training was helpful.

Table 18 presents the results of the likelihood of an association between perceived training helpfulness and the information workers used to make a decision choice in the maintenance scenario. The Fisher's exact test was employed to test if the null hypothesis (that the information workers used to make a decision choice and the helpfulness of the training were not associated in the maintenance scenario) was true.

Table 18. Results of the likelihood of an association between training helpfulness and the information workers used to make a decision choice in the maintenance scenario

Maintenance Scenario				
	Training Helpfulness			
Information Used	Disagree	Neutral	Agree	Total
Safety concerns	0	1	22	23
Indications of problem	0	1	23	24
Peer pressure	0	0	0	0
Productivity	0	0	0	0
Save time and money	0	0	0	0
Total	0	2	45	47

Statistic	P-value
Fisher's Exact Test	0.9999

Results from the analysis failed to reject the null hypothesis (p-value>0.05), indicating that no significant association was observed between the information workers used to make a decision choice in the maintenance scenario and the helpfulness of the training.

This finding suggests that the information workers used to make a decision choice in the maintenances scenario was not influenced by whether the training was perceived to be helpful.

Table 19 presents the results of the likelihood of an association between training helpfulness and the information workers used to make a decision choice in the housekeeping shortcut scenario. The Fisher's exact test was employed to test if the null hypothesis (that the information workers used to make a decision choice and the perceived helpfulness of the training were not associated in the housekeeping shortcut scenario) was true.

Table 19. Results of the likelihood of an association between training helpfulness and the information workers used to make a decision choice in the housekeeping shortcut scenario

Housekeeping Shortcut Scenario				
	Training Helpfulness			
Information Used	Disagree	Neutral	Agree	Total
Safety concerns	0	2	35	37
Supervisor's response	0	0	5	5
Priority of work tasks	0	0	0	0
Productivity	0	0	0	0
Total	0	2	40	42

Statistic	P-value
Fisher's Exact Test	0.9999

Results from the analysis failed to reject the null hypothesis (p-value>0.05), indicating that no significant association was observed between the information workers used to make a decision choice in the housekeeping shortcut scenario and the perceived helpfulness of the training. This finding suggests that the information workers used to make a decision choice in the housekeeping shortcut scenario was not influenced by whether the training was perceived to be helpful.

Table 20 presents the results of the likelihood of an association between training helpfulness and the information workers used to make a decision choice in the inadequate maintenance scenario. The Fisher's exact test was employed to test if the null hypothesis (that the information workers used to make a decision choice and the helpfulness of the training were not associated in the inadequate maintenance scenario) was true.

Results from the analysis failed to reject the null hypothesis (p-value>0.05), indicating that nearly no significant association was observed between the information workers used to make a decision choice in the inadequate maintenance scenario and the perceived helpfulness of the training. This finding suggests that the information workers used to make a decision choice in the inadequate maintenance scenario was not influenced by whether the training was perceived to be helpful.

Table 20. Results of the likelihood of an association between training helpfulness and the information workers used to make a decision choice in the inadequate maintenance scenario

Inadequate Maintenance Scenario				
	Training Helpfulness			
Information Used	Disagree	Neutral	Agree	Total
Safety concerns	0	0	39	39
Peer pressure	0	1	3	4
Productivity	0	0	2	2
Save time and money	0	0	0	0
Total	0	1	44	45

Statistic	P-value
Fisher's Exact Test	0.1333

Results from the analysis failed to reject the null hypothesis (p-value>0.05), indicating that nearly no significant association was observed between the information workers used to make a decision choice in the inadequate maintenance scenario and the perceived helpfulness of the training. This finding suggests that the information workers used

to make a decision choice in the inadequate maintenance scenario was not influenced by whether the training was perceived to be helpful.

Results from the Fisher's exact test indicated several p-values near 1.0000. A p-value near one is uncommon, but possible when using the Fisher exact test. The Fisher exact test assumes the row and column totals in a contingency table are fixed. The p-value is computed by the sum of the probability of all possible distribution of values observed within the table that could equate to the column and row totals (given the row and column totals are fixed). Given these conditions, the size of the p-value is determined by the number of possible distribution of observed values that could equate to the column and row totals. If there were only a few distributions, then a small p-value would result whereas if there were many distributions, then a p-value near one would result. This appears to be the case with many of the data distributions resulting from the decision-making scenarios and information used in the decision-making process.

Implications for Grain Dust Safety Programming

The first and second research questions concerned the association of workers' safety-oriented decision choices with the format of grain dust explosion prevention training and the information workers used to make decision choices with the format of grain dust explosion prevention training. The Fisher's exact test was used to examine the associations. The finding suggests that workers' safety-oriented decision-choice was not influenced by the format of grain dust explosion prevention training. Similarly, the information workers used to make a decision choice was not influenced by the format of grain dust explosion prevention training.

Safety-oriented decision choices made by workers and the information used by them to make a decision choice were not influenced by whether they had taken an online or face-to-face training in prevention of grain dust explosions. The implications of this conclusion to grain dust safety programming, safety education in the grain industry, and industrial safety intervention are that both online and face-to-face training were effective in terms of delivering the knowledge and increasing the awareness of grain dust hazards for this audience. In addition, both online and face-to-face training enabled workers to take grain dust related safety-oriented actions at their workplace. The fact that both groups are taking the training on a voluntary basis suggests that this audience may already have a higher engagement in the subject area than employees who had not chosen to complete the training. The higher engagement in safety content could have also influenced their safety decisions.

The conclusions from the first and second research questions imply that the grain dust explosion prevention training programs offered by OSHA and GEAPS were effective in terms of helping workers make safety-oriented decision choices. Both training programs were able to provide appropriate training materials focused on prevention of grain dust explosions, enabling workers to make safety-oriented decision choices. Yet, training is only one factor in worker decision-making choices. The previous knowledge and experience of workers could also have played a role in their decision choices and the information they used to make these choices. Other factors could have also influenced the decision outcome for workers such as past experiences with grain dust explosions or the level of perceived risk.

The third and fourth research questions concerned the association of level of perceived training effectiveness with the decision choices people who work with grain dust hazards make and the information people who work with grain dust hazards use to make safety-oriented decisions. The finding suggests that safety-oriented decision choices made by people who work with grain dust hazards and the information they use to make decisions were not influenced by their level of perceived training effectiveness. This finding is unexpected because an assumption of training programs is that workers who find the training more effective will also likely be more likely to learn and utilize the material more effectively.

Workers safety-oriented decision-making choices and the information they used to make a decision choice in this case were not determined by whether they perceived the grain dust explosion prevention training to be effective. The implications of this conclusion to grain dust safety programming, safety education in the grain industry, and industrial safety intervention are that workers knowledge and awareness of grain dust hazards were not impacted by whether they perceived training to be effective. This finding is unexpected and contradicts the basis for many “train-the-trainer” programs, which aim to increase the effectiveness of employee training programs. The conclusion warrants additional research to validate the findings drawn in this case.

The conclusions from the third and fourth research questions in this case imply that the level of effectiveness of the grain dust explosion prevention training programs offered by OSHA and GEAPS does not determine workers performance. This is important because this suggests that improvements are needed to make the training more suitable in determining workers performance. This finding was unexpected because previous studies have demonstrated a positive link between training effectiveness and workers performance, where the effects of training positively influenced workers performance through the enhancement of workers competencies and behavior (Elnaga & Imran, 2013). The fact that this audience made safety-oriented decision choices based on given realistic conditions in the simulation suggests that their decision choices may have been determined by other potential factors.

Age could have played a factor in their decision-making process. Older workers are often more knowledgeable, making them more experienced than younger workers (Kanfer & Ackerman, 2004). The investigation of other potential factors influencing workers' decision choice and the information they use to make the decision could help enhance the grain dust explosion prevention training by addressing the factors in the training and as a result enable workers to perform safely at the workplace. Therefore, further research on examining other potential factors influencing workers safety-oriented decision-making choices and the information they use to make those decisions is warranted.

The overall goal of the online and face-to-face training was to increase workers awareness of grain dust hazards. According to the findings, workers safety-oriented decision-making choices and the information workers used to make the decision choices suggested that workers were aware of grain dust hazards. Furthermore, based on the comments made to the question of whether they had done anything different after taking the training, the majority of workers responded that they had taken precautionary measures such as maintaining and upgrading equipment and completing housekeeping tasks as a result of the training. Ultimately, the goals of the training program appear to have been met.

CHAPTER 5. SUMMARY, RECOMMENDATIONS, LIMITATIONS AND FUTURE WORK

Effective training is an important prevention and mitigation method for safety managers and workers. This is especially true for grain dust explosion hazards. The purpose of this study was to evaluate grain dust explosion prevention training in online and face-to-face formats. A short survey instrument was used to collect information on how training information was utilized and how helpful it was in making safety-sensitive decision choices. Data were analyzed using JMP, Pro version 13.1. Frequency and percentages were calculated for all items.

The Fisher exact test was employed to measure how likely the decision choices made by workers and the information workers used to make a decision choice were associated with the format of training and workers' level of perceived training effectiveness. Further, common themes were created from comments made by workers to the question of whether they had done anything different after taking the training provided at the end of survey to examine behavioral change. The results of this research suggest that both the online and face-to-face training in preventing grain dust explosion were effective in terms of conveying the knowledge and increasing the awareness of grain dust hazards. Using the information found in this study, several recommendations can be made.

Recommendations

Both online and face-to-face training were effective in terms of increasing workers' awareness of grain dust hazards. Because of this conclusion, the first recommendation that can be made is that both online and face-to-face training focused on preventing grain dust explosions should continue to be used to provide workers with knowledge of grain dust hazards. Yet, different learning styles exist for different individuals. Some workers may learn more effectively in the online training and some may learn more effectively in the face-to-face training. Online training may be more appropriate for workers who are independent learners, whose daily schedule keeps them from taking a face-to-face training, or who are working in remote areas where face-to-face training may not be available. However, the worker must independently complete the online training and be able to keep up with deadline in order for the training to be effective.

Face-to-face training may be more appropriate for workers who are not competent with the computer or who learn more effectively in an interactive setting. These workers may learn more by talking to colleagues about grain dust hazards and thinking out loud about the hazards in their facilities. Workers who complete face-to-face training must be released from their normal job duties while they complete the training, a situation not always needed in online training formats.

The continuation of offering both training formats will allow the grain industry to best meet the learning needs of all workers who need the training. This is important because this will allow all workers with different learning styles to learn effectively and have the ability to perform safely at the workplace. Therefore, the second recommendation that can be made is that companies in the grain handling and processing industry should offer both online and face-to-face training to workers. This recommendation will not only provide workers with more training options but reach more people who need the training.

The topics covered in both online and face-to-face training were similar, however each format emphasized different topic areas. First, the face-to-face training included topics that addressed potential challenges that workers or supervisors could face when implementing housekeeping practices and preventive measures. These were not addressed at length in the online training. Second, the online training included topics on the importance of preventive training and appropriate responses after a grain dust explosion has occurred. These were not addressed at length in the face-to-face training. Third, the use of a safety audit checklist to help in preventing grain dust explosions was covered in the online training but was not addressed extensively in the face-to-face training.

Limitations

The study has several important limitations. The small sample size decreases the ability to detect effects and substantially lowers the ability to generalize to a larger population of trainees. A total response rate for online and face-to-face training was 25 percent, not unusual for an online survey, but small when considering the targeted population that was surveyed. Several inactive emails were found when the preliminary email was sent to potential respondents, which limited the reach of the survey and decision-making simulation.

Another limitation in the study involved the development of decision-making scenarios. The scenarios were developed mainly by the researcher’s perspective. While there are many decision choices and potential pieces of information workers use to make a decision choice, not all of that information was included in the decision-making simulation. The other limitation involves the Hawthorne Effect, which implies that respondents could have given answers they knew to be correct, but that may not have reflected their true decision choice, if confronted with an actual scenario involving grain dust hazards.

Third, the researchers recognize that knowledge learned in the training plays only a partial role in how workers may respond to grain dust safety scenarios. Other factors can also influence the decision choice and the information used to make the choice, including previous experience and knowledge, experience handling grain, a previous experience with a dust explosion, and other factors. These factors may have played a larger role in the decision-making process and the researchers readily acknowledge this.

Future Work

The research conducted in this project was an evaluation of the effectiveness of two formats of grain dust explosion prevention training using decision-making simulation. The four-level Kirkpatrick evaluation model was used as a framework to evaluate the two formats of grain dust explosion prevention training. The future research that can build upon this project includes:

- Examining other potential factors that could influence workers safety-oriented decision-making choice
- Examining other potential factors that could influence the information workers use to make decision choices
- Further investigating the linkages between workers' perception of training effectiveness and their decision choices
- Further investigating the linkages between workers' perception of training effectiveness and the information they use to make decision choices.
- Examining the use of the four-level Kirkpatrick evaluation model in other safety-related fields.

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APPENDIX A. SURVEY INSTRUMENT

Housekeeping
You are in the headhouse and you notice the area could use some housekeeping. You make a mental note to sweep the area later. You speak with your supervisor about the needed housekeeping later in the day, but the supervisor tells you that housekeeping can be delayed and that the area is not dusty enough to make housekeeping a priority. You know that grain dust can be hazardous. What decision choice would you make in this scenario?

Option A: Assume someone else will clean up
Option B: Sweep immediately
Option C: Persuade your supervisor
Option D: You never get to it

What factors drove your decision choice?
Factor 1: Low chance of safety issue
Factor 2: Safety concerns
Factor 3: Supervisor response
Factor 4: Job responsibilities
Factor 5: Productivity

Maintenance
You and a colleague are monitoring bucket elevators. A sensor alarm goes off, indicating that a bearing temperature has reached a critical level. Your colleague brushes off the alarm, telling you that it has gone off several times and nothing has happened. You suspect the bearings are out of grease and this is causing it to overheat. What decision choice would you make in this scenario?

Option A: Follow your colleague's advice
Option B: Take precautions
Option C: False alarm
Option D: Prevention of future alarms

What factors drove your decision choice?
Factor 1: Indications of problem
Factor 2: Productivity
Factor 3: Safety concerns
Factor 4: Peer pressure
Factor 5: Save time and money

Housekeeping Shortcut
You are in the gallery (bin deck) and you notice that the area could use some housekeeping. You speak with your supervisor about the needed housekeeping, but your supervisor tells you that housekeeping can wait until later and to sweep the dust underneath the conveyors for now. You know that even a little bit of grain dust can be hazardous. What decision choice would you make in this scenario?

Option A: Follow your supervisor's advice
Option B: Promise to clean before the end of the day
Option C: Approach your supervisor
Option D: Stop working and clean the area

What factors drove your decision choice?
Factor 1: Supervisor's response
Factor 2: Priority of work tasks
Factor 3: Safety concerns
Factor 4: Productivity

Inadequate Maintenance
You and a colleague are maintaining a bucket elevator. You notice that a section of the belt is worn. Your colleague tells you that splicing the belt to replace this section can wait because nothing has happened and that the bucket elevator ran just fine during operational hours. What decision choice would you make in this scenario?

Option A: Repair the belt
Option B: Follow your colleague's advice
Option C: Replace the belt later
Option D: Talk to your colleague about repairing the belt

What factors drove your decision choice?
Factor 1: Peer pressure
Factor 2: Productivity
Factor 3: Safety concerns
Factor 4: Save time and money

APPENDIX B. OPEN-ENDED COMMENTS

Have you done anything different at your workplace after taking the training?			
Yes			No
Housekeeping	Dust Collection Systems	Precautionary Measures	No Action Taken
• Attempt to keep housekeeping controlled earlier and more often • Focused on cleaning my worker area, where I work and I am constantly looking out for dust • We have become more intentional with making housekeeping a priority and have started cleaning some areas we didn't before such as the head space of flat buildings • I have updated our in-house housekeeping program to help decrease the accumulation of dust • Looked more closely for areas where dust can collect. Notified plant supervisor of areas in need of cleaning • Yes, low tolerance for neglecting housekeeping. Safety inspects every two weeks • I manage high priority areas much differently than what used to be done in the plant making sure we stay under acceptable guidelines • changed the way our housekeeping is done in the plant especially around electrical components • I've paid more attention and focused more on the importance of housekeeping • I have been delegating cleaning as priority • Monitor housekeeping and assign areas of concern	• Yes, we now have dust collecting systems to try and prevent any explosions from happening • Reviewed where dust systems are located to determine their effectiveness • Yes, looked for hidden dust more closely, installed new central vacuum system	• I do a daily walk-through of the grain receiving and storage areas looking for leaks or maintenance issues and following up with immediate clean-up if needed. We do weekly cleaning of the entire grain handling facility to keep the dust accumulation to a minimum. These procedures mitigate the risk of a secondary explosion from grain dust and our facility is "audit ready" at all times • Yes, I repaired our Hazmon system • Upgrading conveying equipment conveying to eliminate escaping dust • Revisited safety procedures already in place and increased emphasis on precautionary measures (i.e. prepping area prior to work)	• I have not, but I have been more aware of it • I am a student, unemployed. Haven't had the chance to practice

APPENDIX C. INSTITUTIONAL REVIEW BOARD (IRB) APPROVAL

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office for Responsible Research
Vice President for Research
2420 Lincoln Way, Suite 202
Ames, Iowa 50014
515 294-4566

Date: 5/31/2017

To: Wesley Chang
3332 Elings Hall
605 Bissell Road

CC: Dr. Gretchen Mosher
104 I Ed II

From: Office for Responsible Research

Title: Evaluating the Effectiveness of Grain Dust Prevention Training in Online and Face to Face Formats

IRB ID: 17-238

Study Review Date: 5/31/2017

The project referenced above has been declared exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b) because it meets the following federal requirements for exemption:

- (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey or interview procedures with adults or observation of public behavior where
  - Information obtained is recorded in such a manner that human subjects cannot be identified directly or through identifiers linked to the subjects; or
  - Any disclosure of the human subjects' responses outside the research could not reasonably place the subject at risk of criminal or civil liability or be damaging to their financial standing, employability, or reputation.

The determination of exemption means that:

- **You do not need to submit an application for annual continuing review.**
- **You must carry out the research as described in the IRB application.** Review by IRB staff is required prior to implementing modifications that may change the exempt status of the research. In general, review is required for any modifications to the research procedures (e.g., method of data collection, nature or scope of information to be collected, changes in confidentiality measures, etc.), modifications that result in the inclusion of participants from vulnerable populations, and/or any change that may increase the risk or discomfort to participants. Changes to key personnel must also be approved. The purpose of review is to determine if the project still meets the federal criteria for exemption.

  Non-exempt research is subject to many regulatory requirements that must be addressed prior to implementation of the study. Conducting non-exempt research without IRB review and approval may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.

  Detailed information about requirements for submission of modifications can be found on the Exempt Study Modification Form. A Personnel Change Form may be submitted when the only modification involves changes in study staff. If it is determined that exemption is no longer warranted, then an Application for Approval of Research Involving Humans Form will need to be submitted and approved before proceeding with data collection.

Please note that you must submit all research involving human participants for review. **Only the IRB or designees may make the determination of exemption**, even if you conduct a study in the future that is exactly like this study.

Please be aware that **approval from other entities may also be needed.** For example, access to data from private records (e.g. student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. **An IRB determination of exemption in no way implies or guarantees that permission from these other entities will be granted.**

Please don't hesitate to contact us if you have questions or concerns at 515-294-4566 or IRB@iastate.edu.