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It is entitled:
Evaluating Training Approaches for the Revised NIOSH Lifting Equation

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Evaluating Training Approaches for the Revised NIOSH Lifting Equation

A dissertation submitted to the

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Doctor of Education

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by

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Abstract

The goal of this study was to determine whether the Revised NIOSH Lifting Equation (RNLE) CD-ROM training program, when used without an instructor, could adequately train RNLE users to properly understand and correctly apply the RNLE. If so, then it can be used to fill a current gap in delivering training to both health and safety professionals, and RNLE end-users that do not have access to instructors or traditional classroom training. Combinations of different training methods (computer-based via CD-ROM versus text-based, and instructor directed versus self-directed/self study) were evaluated as to their effectiveness in enhancing knowledge and skills regarding the proper use of the RNLE. Participants were assigned by classroom units to one of four different instructional groups: instructor led using CD-ROM, self study using CD-ROM training, instructor led using printed text, and self study using printed text. The effectiveness of the training was evaluated using written pre and post-training tests to determine the relative quality and appropriateness of the training materials and their delivery methods. Of particular interest was the performance of the self study using CD-ROM training group compared to both the self study using printed text and the instructor-led using text groups. The CD-ROM self study (without an instructor) was found to be significantly more effective than both the self study using printed text and the instructor-led using text with regards to training in the correct and accurate use of the Revised NIOSH Lifting Equation.
Acknowledgements

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Chapter One: Introduction and Review of the Literature

Statement and Significance of the Problem

Lower back pain is one of the most common and significant musculoskeletal health problems facing society today, with occupation-related low back disorders (LBDs) being reported in epidemic proportions. Chronic back pain resulting from both work-related injuries and everyday life activities continues to be an ongoing health problem for the general population. There were 22 million cases of back disorders reported in 1988. (Guo, Cameron, Seligman, Behrens, Ger, Wild, and Putz-Anderson, 1995). As early as the 1980’s, Andersson (1981) reported that the lifetime prevalence of low back pain (LBP) alone was estimated to be as high as 70% for the general population.

In 2001, the back was involved in nearly one-fourth of all nonfatal occupational injuries and illnesses (BLS, 2003c). Also in 2001, the Bureau of Labor Statistics (BLS) reported 372,683 back injury cases involving days away from work, with workers having a median of six days away from work (BLS, 2003a, b). Considering the median number of days away from work per back injury and the total number of those with back injuries, the economic costs due to lower back injuries and illnesses are staggering. Reports from national insurers on workers’ compensation claims indicate that back injury claims accounted for 16% of all workers’ compensation claims and 33% of total claims costs (Webster and Snook, 1994). It has been estimated that the total yearly cost of low back pain was between fifty and one hundred billion dollars (Frymoyer and Cats-Baril, 1991). Leigh estimated that the total indirect and direct costs combined for occupational low back pain for 1992 was 49.2 billion dollars. This was equivalent to 34% of the total cost for that year of all occupational injuries and illnesses combined (Leigh, Markowitz, Fahs, Shin, and Landrigan, 1997).
Garg and Moore (1992) found that back injuries were linked to occupational activities that placed excessive biomechanical and physiological loads on the worker’s body, for example lifting, pushing, pulling, and carrying. In a later report of the evidence for work-related musculoskeletal disorders, the National Institute for Occupational Safety and Health (NIOSH) concluded that “there is strong evidence that low back disorders are associated with work-related lifting and forceful movements” (NIOSH, 1997). Many American workers are employed in jobs routinely requiring them to perform activities associated with work-related back pain (NIOSH, 1989).

To aid in the prevention of lifting-related lower back injury, NIOSH developed the Revised NIOSH Lifting Equation (RNLE), to calculate a recommended weight limit (RWL), and lifting index (LI) used for estimating the physical demands of the job (Waters, Putz-Anderson, Garg, and Fine, 1993). NIOSH research has revealed that use of the Revised NIOSH Lifting Equation can identify tasks with an increased risk of causing lower back pain and subsequently lower back injury (Waters, Baron, Piacitelli, Anderson, Skov, Haring-Sweeney, et al., 1999). Furthermore, when properly applied the Revised NIOSH Lifting Equation can be used to evaluate a complete manual lifting task or parts of the task so as to reduce the overall possibility of lower back pain or injury.

The Revised NIOSH Lifting Equation has gained widespread popularity in the United States and internationally as a tool for assessing the physical demands of two-handed manual lifting tasks. Countries in the European Union have used the Revised NIOSH Lifting Equation as rationale for establishing guidelines and standards for manual materials handling (Fallentin, Viikari-Juntura, Waersted, and Kilbom, 2001). These guidelines were included as components of the standards of the European Committee for Standardization (CEN), as part of a general
model aimed at improving workplace ergonomics.

In order to properly use the Revised NIOSH Lifting Equation, accurate and precise measurements of input data are required (Waters, Putz-Anderson, and Garg, 1994). A NIOSH report concluded that; (a) adequate training is necessary to accurately conduct the precise measurements required for the Revised NIOSH Lifting Equation; (b) it is possible to train individuals to make the required measurements accurately; and (c) the training should include clear instructions on what to measure and how to measure it (Waters, Kemmlert, and Baron, 1998). A 2001 study (Influence of measurement accuracy on the application of the 1991 NIOSH equation) revealed a problem with measurement and accuracy in evaluating the parameters used in applying the Revised NIOSH Lifting Equation, with the frequency and horizontal location parameters having the highest errors (Dempsey, Burdorf, Fathallah, Sorock, and Hashemi, 2001). Based on anecdotal reports, users of the Revised NIOSH Lifting Equation noted that it was extremely difficult to rely on the Revised NIOSH Lifting Equation text alone to make the measurements required to both correctly and accurately apply the Revised NIOSH Lifting Equation. Furthermore, it is not feasible for NIOSH personnel or other experts to conduct face-to-face training for all potential users. This is because of the lack of expert instructor availability and a requirement to make calculations or alter lifting tasks conditions in the field and in real time. Therefore, a training curriculum that can visually demonstrate how to make the required measurements and be globally distributed to safety personnel and other users is greatly needed.

**Review of Learning and Training Delivery Methods**

Multimedia computer-based training can provide interactive demonstrations that illustrate the impact of changing the components of a lifting task. Self-directed, or “self study” learning, using real time (multimedia) computer-based training is advantageous in that the
trainee immediately receives feedback as to the impact of various changes in the components of the lifting task that would be used to determine the best task design. The trainee receives this feedback both via text and audio-visually.

Effective training is imperative if the Revised NIOSH Lifting Equation is to be properly used in preventing work-related injuries resulting from manual lifting. The forms of training that have been previously available have included instructor-led courses, and written texts, such as the Applications Manual for the Revised NIOSH Lifting Equation (Waters, Putz-Anderson, and Garg, 1994). While this is an excellent descriptive text, it may not provide the necessary feedback needed to insure the effective training in correctly and accurately using the Revised NIOSH Lifting Equation. Alternatively, while an instructor typically facilitates learning the knowledge and skills for the effective use of the Revised NIOSH Lifting Equation, the availability of qualified instructors is limited due to multiple factors such as location of the training or work site and the lack of trained instructors. One means to address current training needs is through the use of an interactive multimedia program delivered via CD-ROM or the internet.

Differences of opinion exist with respect to the impact of technology enhanced learning. Proponents of using of computer technology in training maintain that it makes learning more efficient and interesting. Positive outcomes can include the flexibility to meet individual learning and schedule needs, greater and more efficient access to educational information and resources, and enhanced educational materials through hypertext, virtual and simulated contexts. However, negative outcomes are also possible, which may include the need for access to expensive technology, less face-to-face and interpersonal interaction, limited user technology skills (typing ability, software familiarity), and potential information overload.
Differences are also noted in the research literature regarding the effectiveness of technology on learning and development outcomes. Reviews of literature have provided evidence that technology enhanced learning has a positive impact on the over-all learning process of the students. In a meta-analysis of 17 studies, Soe (2000) noted that computer-aided reading instruction had a positive impact on the reading achievement of K-12 students (Soe, 2000). However, other researchers have maintained that their research reviews do not present overwhelming support for the effectiveness of technology enhanced learning (Russell, 1999; Parr, 2002). These researchers maintain that additional research is needed in order to examine the impact of the various and different components of the computer-based learning experience, such as the content, instructional approaches, learning styles of the learners, and the interactions of these components.

In Russell’s (1999) controversial No Significant Difference Phenomena, a review of 355 research reports from the last 25 years revealed no significant differences in learning outcomes between educational settings that used technology and those that did not use technology. In addition, based on a review of reviews, meta-analyses, and large scale studies examining the effectiveness of computer-assisted instruction and integrated learning systems, Parr (2002) noted there was a lack of consistency in the findings with respect to knowledge/achievement gains. Variation among student performance was demonstrated with respect to student learning characteristics, instructional approaches, role of the teacher, level of student access to technology, and the levels of social interaction (Parr, 2002). A meta-analysis titled Relative Effectiveness of Worker Safety and Health Training Methods, by Burke, Sarpy, Smith-Crowe, Chan-Serafin, Salvador, and Islam (2006), provided evidence that training using behavioral modeling with practice and feedback was generally more effective than other methods of safety
and health training. Behavioral modeling involves the observation of a role model, which then can be followed by practice, with the ultimate goal of modifying a behavior. The authors found that the most engaging methods of training were the most effective, and in some cases as much as three times more effective than the least engaging methods. The “most engaging” methods consisted of hands-on training involving interactions between trainees and trainers, although some of the studies classified as most engaging could have included computer simulations as a form of modeling. The authors listed the least engaging methods as lectures, films, and video-based training. Although they make an argument for the effectiveness of the most engaging methods of training, they state that “unexpectedly, the least, moderate, and most engaging safety and health training methods had somewhat comparable overall mean levels of effectiveness with respect to improvements in behavioral performance” (Burke, Sarpy, Smith-Crowe, Chan-Serafin, Salvador, and Islam, 2006). Because of this disagreement with the interpretation of their own findings, they cautiously interpret their results and blame them on the ambiguity in classification of the training tasks as least, moderate, or most engaging.

Research on training effectiveness has also compared traditional instructional approaches with technology enhanced instruction. Comparing student performance from online versus face-to-face nutrition courses, researchers found no significant differences for gains in knowledge between these two groups of students (Miller, Cohen, & Beffa-Negrini, 2001). No significant differences were found between younger and older students. After standardizing for lectures, exams and text, Schutte (1997) found different results, where students attending virtual sociology classes had higher midterm and final exam grades (Schutte, 1997).

While computer-based instruction has been typically viewed as an effective and efficient replacement for instructor-led instruction, current research is now combining these two
instructional approaches to produce enhanced learning environments. Also referred to as “blended learning,” this hybrid instruction integrates technology-enhanced instruction with traditional classroom instruction. This approach combines the convenience and self-paced characteristics of the computer-learning format with interactive, instructor-led experiences that work to facilitate complex discussions and skill development. For example, hybrid instruction may consist of:

- Instructor-led course with ongoing email discussions from content experts
- Self-paced individual online instruction combined with hands-on classroom based learning that practices the designated skills.

The hybrid instructional model is being incorporated into several workplace safety training programs undergoing study at NIOSH, such as electrical and respirator safety training. The Federal Emergency Management Agency (FEMA) is also developing computer-based hazardous materials safety training for emergency responders. This computer-based training will be combined with a short period of face-to-face instruction to provide emergency responders with their certification. This hybrid instruction will replace the current five day face-to-face instruction. Currently, volunteer responders have difficulty attending the five day instruction because of their full time jobs. The computer-based instruction enables these responders to learn part of the material within their own schedules. The face-to-face portion of the training provides them with the hands on practice in developing safety operation skills. Another example of using the hybrid instructional model is The Center to Protect Workers’ Rights (CPWR) and Georgia Institute of Technology are developing computer-based confined space safety training. The computer-based portion of the training will be combined with classroom based instruction in order to provide more convenient and flexible training schedules for workers. The challenge
inherent in hybrid instruction is effective integration of the different delivery mechanisms together without compromising the learning environment.

Tuckman (2002) compared groups of students who participated in traditional classroom instruction with students participating in hybrid classrooms. After controlling for prior achievement, students in hybrid classrooms had significantly higher grade point averages (GPA’S) than students in the traditional classrooms. Black (2001) found that students rated hybrid instruction more positively than students receiving traditional instruction. The purpose of the Revised NIOSH Lifting Equation CD-ROM training program is to further the investigation of any potential differences between traditional, technology-enhanced, and hybrid models of instruction.

**Justification for the Study**

Lifting tasks are a required part of the normal everyday jobs performed by many workers. These job-related tasks involve lifting and moving objects of a wide range of sizes and weights. These job-related tasks may also require objects to be moved various distances, either horizontally or vertically. Low back pain and back injuries are the most frequently reported occupational injuries consistently attributed to improperly designed manual lifting activities. A lack of attention to the design of lifting tasks can increase the risk of injury to workers. Worker injuries decrease overall productivity, increase worker medical leave time, and injury related medical costs. There is also a cost, in both time and money associated with replacing injured workers.

The National Institute for Occupational Safety and Health (NIOSH) developed the Revised NIOSH Lifting Equation (RNLE) for determining the recommended limits for manual lifting tasks. This equation can be used to facilitate the design of safer manual lifting tasks.
After a work job is chosen, and the task design to effectively accomplish the lifting portion of the work is identified, the lifting equation is then used to interpret the safety of the lifting task and to make decisions regarding whether or not this is the safest possible design. One of the challenges facing employers, health and safety professionals and others interested in manual lifting, is that these lifting tasks are frequently implemented quickly onsite in an effort to meet production or other site-related requirements. The evaluation as to the efficacy and safety of the lifting task may be conducted later. At that time, if problems are noted, the lifting task must be redesigned in the field and in real time. Unfortunately worker injury may have already occurred. What is needed is a means of evaluating the safety of a lifting task both pre-onsite and onsite before an injury has occurred.

The Revised NIOSH Lifting Equation provides one practical method that can be used to evaluate the safety of lifting tasks that may have to be, or have been incorrectly altered to fit site-specific conditions. The Applications Manual for the Revised NIOSH Lifting Equation (Waters, Putz-Anderson, and Garg, 1994) described the equation and provided explanation on its use and application. Anecdotal reports suggested that the text, while useful, was complicated and difficult to understand. Noted was the difficulty in understanding the text’s description of making measurements required to correctly and accurately use the lifting equation. To better prepare employers, safety professionals, and other interested users on how to use the Revised NIOSH lifting equation, this author developed an instructional Multimedia CD-ROM based computer program. That product was evaluated in this study.

While widely used approaches to training are through written instruction (text) and instructor-led classes. Instructor-led training is time intensive and expensive. Multimedia computer programs (CD-ROM and web) are becoming more commonly used as an instructional
method for conducting workplace safety training. However, additional research is needed on the effectiveness of computer-based multimedia training with regard to enhancing safety knowledge, attitudes, and workplace performance. Specifically, there has been little research examining the most effective way to impart the complex knowledge and skills required to properly utilize the Revised NIOSH Lifting Equation.

Overview of the Study

This study evaluated the effectiveness of the NIOSH multimedia (CD-ROM) training program for the Revised NIOSH Lifting Equation by comparing it to traditional teacher-led instruction, as well as with self study (also described as “self directed”) learning where students direct their own learning by either reading the text or using the CD-ROM without an instructor. This study examined learner gains in knowledge, and skills regarding the use of the Revised NIOSH Lifting Equation. Also examined was the ability of students to design safe manual lifting tasks after completing training. In addition, by comparing traditional text and instructor-led training with multimedia computer-based methodologies, this study determined whether the use of multimedia technologies for complex training was simply on par with other methods (written text), or enhanced learning and performance.

Intended Use of Study Findings

Study results were ultimately used to finalize and prepare the CD-ROM product for dissemination to health and safety professionals and others interested in manual lifting, such as design engineers. The CD-ROM is intended as an aid to learning how to use the Revised NIOSH Lifting Equation. Findings from this study may influence NIOSH recommendations with regard to the development of additional multimedia training materials. For example, data and
information from this study may help to identify factors and conditions critical to effective training in the correct and accurate use of the Revised NIOSH Lifting Equation and in the use of e-products in general.
Chapter Two: Methods

Study Objectives

1. Conduct comparative analysis of training conditions that reflect differences in instructor conditions (with or without a live instructor) and technology involvement (with or without CD-ROM based didactic material), with respect to knowledge gains and problem solving skills.

2. Evaluate training processes in all four groups with particular attention to subjects’ efficiency and satisfaction with the use of computer-based CD-ROM technology as a tool to facilitate their learning, compared to studying only the text, or participating in a traditional classroom setting.

Specific Hypotheses

1. Subjects trained with the Revised NIOSH Lifting Equation CD-ROM will show significant improvement over baselines in knowledge and skills regarding the correct and accurate use of the Revised NIOSH Lifting Equation.

2. Subjects trained with the Revised NIOSH Lifting Equation CD-ROM (which incorporates interactive multimedia) will show comparable gains in knowledge and skills as compared to subjects trained via a written text.

3. Subjects trained with the Revised NIOSH Lifting Equation CD-ROM (which incorporates interactive multimedia) with an instructor in a traditional classroom setting will show equal or greater in knowledge and skills compared to subjects trained using a written text with an instructor in a traditional classroom setting.

4. Subjects trained with the Revised NIOSH Lifting Equation CD-ROM in the self study
groups (without an instructor) will perform at an equal level (show comparable gains in knowledge and skills) or better than those of both the text alone and the traditional instructor–assisted textbook classroom groups.

**General Research Approach**

The research approach includes both descriptive and confirmatory elements. Qualitative data explore factors with regard to training processes and procedures in each of the four conditions. Quantitative data was used to assess hypothesis testing regarding comparative performance of the student’s knowledge and skills before and after training.

**Pilot Studies**

Three pilot studies, each with one subject were conducted with the CD-ROM in order to solicit user input regarding any content or technology glitches that might need to be corrected before a final version of the CD-ROM was available for the full study. In addition, the evaluation instruments were piloted to determine their feasibility and content validity. Additional information concerning the times required to complete the surveys was gained from the pilot studies. This allowed for better planning of times given for completion of each condition. Participants in the pilot study were one full time employee of NIOSH with some knowledge of, but no experience with the Revised NIOSH Lifting Equation. The second pilot participant was a graduate NIOSH summer intern with no knowledge of the Revised NIOSH Lifting Equation, and the final pilot participant was a NIOSH co-researcher with a working knowledge of the Revised NIOSH Lifting Equation.

The pilot studies utilized the Revised NIOSH Lifting Equation CD-ROM, and each was a single event that lasted no more than three hours and thirty minutes. Subjects were given 120
minutes to review the CD-ROM material included in Lesson One and then completed evaluations addressing knowledge gains, problem solving abilities, and satisfaction with the material. Following this period, subjects participated in informal individual interviews that lasted 60-90 minutes so as to discuss their experiences in reviewing and learning the CD-ROM material, and to provide any suggestions for improvements. Information collected during individual interviews was in the form of handwritten notes by the observer/researcher. No personal identifiers were recorded in the data and subjects agreed to voluntary inclusion in the study. Limited behavioral observations were conducted of the subjects while they were working through the CD-ROM in order to fine-tune a behavioral observations checklist that was used in the initial runs of the full study. Based on the collected data and subject feedback, improvements were made to the content and technological framework of the CD-ROM training program and to the knowledge and assessment instruments that were used in the full study.

Even though subjects were NIOSH employees, prior to their participation in the pilot study they were informed of their rights as subjects. As subjects, they were told that they had the right to withdraw from the pilot study at any time without penalty or prejudice, and that their withdrawal would be kept confidential.

The pilot study was not identical to the full study as the full study took place within the framework of an actual university program-based course (class in a traditional classroom) and it was determined to be too problematic to have a “test run” with an actual course. Additionally, a pilot of the entire program would have allowed a much greater chance of contamination of the overall subject pool by “word of mouth” spreading of the study content.

For the pilot studies, the CD-ROM training program was self-administered by the subjects but was proctored by the study researcher. The computer equipment used in the pilots
was technologically identical to, or technologically nearly the same as those used for the full study. Subjects in the full study will be allowed to use their own personal computers, in addition to those provided by the various universities. This makes it impossible to have identical equipment for each subject in both the pilot and full studies.

For the pilot studies, each subject’s data was collected in the form of written evaluations, informal interviews, and behavioral observations by a researcher. Findings were used to guide any final improvements made to the training materials, written evaluation instruments, and behavioral observers’ checklists. Subjects in the pilot were not allowed to participate in the full study.

**Participants (Subjects in Full Study)**

There were a total of 415 subjects which were divided into four training conditions. These were divided into Twenty-two (22) randomly selected training groups. Table 1 provides a summary of training groups and subjects per condition.

<table>
<thead>
<tr>
<th>Table 1. - Training Groups and Subjects by Condition</th>
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<tbody>
<tr>
<td>Condition</td>
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<tr>
<td>-----------</td>
</tr>
<tr>
<td>Text Only</td>
</tr>
<tr>
<td>Text with Instructor</td>
</tr>
<tr>
<td>CD-ROM</td>
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<tr>
<td>CD-ROM with Instructor</td>
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<tr>
<td>Total All (4) Conditions</td>
</tr>
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</table>

**Measurement Procedures**

Because the study took place within established university courses, attendance was monitored by university instructors as is currently required by the college for grading purposes. Subjects recorded their names on a sign-in sheet at the beginning of training sessions in order to
verify attendance. Subjects also recorded their personal names on the written evaluations. The study researcher administered all pre-test and post-test evaluations, and collected the evaluations upon their completion. Subjects were assured that their responses on the evaluations would be kept confidential. For quality control, an observer-researcher made random site (classroom) visits to observe training sessions. This helped ensure the quality of the collected data and the administration of the training. Every effort was made by the observer to be unobtrusive at the training sessions. The university instructors were also queried as to their impression of any adverse influences due to the presence of the observer. There were no adverse affects found due to the observers’ presence.

Moderating variables included factors related to subject characteristics or characteristics of the instructional surroundings such as the size of the class and location of the classroom. Individual confounders included the educational background of the subject, the experience level of the subject such as the level of computer expertise, and prior knowledge of the subject about lifting equation related materials. Random assignment of the subjects and university instructors to the four training conditions was attempted but do to the objections from some university instructors, was difficult to strictly adhere to. Two of the instructors’ would only allow use of their class if a specific condition was administered. Randomization was attempted by using a condition-labeled chip drawing. Additional randomization was somewhat obtained by using an odd-even method of scheduling for those two instructors. This is deemed a limitation of the study. Prior experience with the lifting equation and with e-learning technologies was also deemed a limitation of the study. Prior attitudes’ of the subjects about computers and technology was addressed via a questionnaire. (pre-test evaluation). Of particular interest was whether a
subject had attended a class taught using CD-ROM software. Although this information was obtained, it was not statistically evaluated as a result for this study.

As previously noted, a random selection of behavioral observations was conducted by a NIOSH researcher during the training. Behavioral observations were recorded using a behavioral observations check-list (included in the appendices as an attachment). Classroom location and identity of the university instructor as well as the training tasks being observed were recorded. No other personal or situational identifiers were recorded. Only aggregate data was used to report the findings in order to protect the identity of the subjects. Observational data provided global, qualitative information as to the situational validity of the classroom for all four training conditions. There were no observations of gross deviations from the planned study curriculum.

Training Sites

Data was collected in existing classroom settings at the University of Cincinnati, The Ohio State University, Wright State University, and Raymond Walters College. Selection of subjects to participate was based on a convenience sample of appropriate subject matter classrooms at the participating universities. As previously stated, random selection was attempted by drawing condition labeled chips from a hat, although this process was confounded somewhat by class-room professors choosing to participate in only one type of condition. This was a problem with only two groups involved in this study. The twenty two training groups varied in group size because of class enrollment. The smallest class (group) size was six and the largest was thirty-seven. There was one group of one subject and care was taken to give this lone subject the same equal time and material exposure as given to other (larger) groups. Care was taken to guarantee that conditions did not occur where subjects would have had an
opportunity of contact with colleague or cohort subjects in another classroom participating in the study, there-by possibly contaminating the study pool. This was strongly guarded against and was presumed not to have occurred. Assignment of same University study groups (classes) given in the same general time-frame (quarter or semester) were all made to identical treatment conditions. Consequently, if subjects from different classrooms did share information, the evaluations comparing the effectiveness of the instructional approaches were not compromised. Moderating variables included factors related to subject characteristics or characteristics of the instructional surroundings such as the size of the class and location of the classroom. Some classes were held in dedicated computer rooms while others were held in classrooms with available computers. This was not a problem as all computer equipment met minimum study standards. Individual confounders of interest included the educational background of the subject, the experience level of the subject such as the level of computer expertise, and prior knowledge of the subject about lifting equation related materials. Prior knowledge of lifting equation related material was addressed thru a pre-study evaluation, but was not statistically addressed as a part of this study.

**Study Design and Procedure**

Prior to their involvement in the study, subjects signed an informed consent document. Subjects both read and were explained all factors as listed on the informed consent and an accompanying fact sheet addressing any risks involved in or as a result of this study. Subjects were at that time given the opportunity to not participate and it was restated that they could withdraw from the study at anytime without fear of reprisal. Both the informed consent and fact sheet are included in the attachments section of this paper.
A pre/post experimental design with treatment and control groups was used. The research design was a mixed design with two between subjects’ factors (type of media and instructor presence) and one within subjects’ factor (testing conditions-pre and post). Selected classrooms were randomly assigned to one of the three treatment groups (CD-ROM self study, CD-ROM with live instructor, printed text with live instructor) or the control group (self study of printed text). Table 2 provides a summary of the experimental design and treatment conditions. The within subjects factor is associated with repeated measures of changes occurring as a result of pre-training and post-training conditions thus providing information on each participant about any changes in their knowledge, or problem solving skills.

Comparative analysis of the four groups using subjects as the unit of analysis was conducted to evaluate the relative effectiveness between the training conditions with respect to subject knowledge, and problem solving skills. Attitudes about the training, and satisfaction with their training methodology were addressed via questionnaires to be evaluated subjectively. Table 2 provides a summary of the four treatment conditions.

<table>
<thead>
<tr>
<th>Learning Medium</th>
<th>Instructor Type</th>
<th>Learning (Treatment) Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text only. Do not receive CD-ROM</td>
<td>No Instructor</td>
<td>“Control” group - Subjects to learn material on their own (“self study”) without aid of CD-ROM or instructor</td>
</tr>
<tr>
<td>Instructor-Led</td>
<td>Reflects “traditional” classroom instruction - Subjects received training with instructor and printed textbook</td>
<td></td>
</tr>
<tr>
<td>Received CD-ROM.</td>
<td>No Instructor</td>
<td>Subjects learn material on their own (“self study”) using CD-ROM</td>
</tr>
<tr>
<td>Instructor-Led</td>
<td>Subjects learned using CD-ROM and also had direction and input from instructor. The instructor also had the CD-ROM as a resource and included it in instruction.</td>
<td></td>
</tr>
</tbody>
</table>
All classroom training was conducted by the study researcher. Some subjects had been previously exposed to lifting equations and to the Revised NIOSH Lifting Equation by university faculty who already teach the Revised NIOSH Lifting Equation as part of their curriculum. This possible confound was addressed via a survey questionnaire covering both exposure to lifting equations in general and specifically The Revised NIOSH Lifting Equation. The training consisted of one to three weekly sessions, depending on the scheduled meeting times, class-time availability, and treatment condition. The sessions lasted the length of the classroom period, ranging from 50 minutes to 150 minutes. Total instructional times were kept the same for all instructor led conditions.

The instructional content was the same for all the instructor led conditions and was taught using a study guide. The order and content for all self study conditions were the same as an instructional outline and time-line were followed as a guide for administering the study and related materials. The same researcher administered all conditions in this study. Due to varying class-time lengths and variations in the number of class meetings per week, it was impossible to have identical numbers of meeting times per week and duration times per meeting. This was controlled for by adhering to precise time, order, and content of the material presented to each group and in all same-type conditions (instructor or self study). Research was completed within the time-line of eight academic quarters.

Study administration times had to be scheduled based on the availability of university instructor provided class times, and in several cases the study had to be re-scheduled. This was done without any problems and was deemed a non-issue with regards to the study. As previously addressed, care was taken not to deviate from the planned training curriculum. This occurrence (possible curriculum deviations) could not be totally controlled for, since there were
questions from subjects during the training, but it was not a factor because of strict adherence to
the study guide.

Only aggregate data was used to report the findings in order to protect the identity of the
subjects. Because the primary researcher administered all study lectures and materials, an
independent researcher observer was utilized during the first several study runs. The observer
reported no problems relating to the first several study runs, and quality control regarding the
experimental conditions was deemed excellent. Because of no problems related to the study, the
observation process was deemed unnecessary and discontinued at that time.

Prior to initiating the Revised NIOSH Lifting Equation CD-ROM study, university
instructors teaching the courses to be used were given background information and study
materials—either the CD-ROM, written text, or both. They were allowed to review the Revised
NIOSH Lifting Equation written text and CD-ROM materials and the instructional approaches
that were to be used, as well as to address any questions or concerns about the study. The
university instructors also received guidelines outlining the instructional approaches used in this
study.

These guidelines emphasized the importance of the university instructors’ role and
thanked them for their participation. In addition, the guidelines also provided information on
how the Revised NIOSH Lifting Equation training study would be administered, the expected
content of the training sessions, and the importance of preserving the confidentiality of the
subjects. This was done as a courtesy, even though the study was administered and all
instruction was given by the study researcher. University instructors were also allowed to
remain in their classrooms as observers if they so desired. Care was taken not to deviate from
the planned training curriculum. As previously addressed, this occurrence (possible curriculum
deviations) could not be controlled for, since there were questions from subjects during the training and therefore this was regarded as a possible limitation of the study.

**Critical Element: Use of Standardized Computing Technologies**

Standardized Computing was used for all conditions as the Revised NIOSH Lifting Equation CD-ROM requires a minimum hardware and software technology to operate efficiently and perform its designed functions. These standards were established and verified formatively at NIOSH. All computers available to subjects in classrooms or through the various university computer labs met or exceeded these minimum standards consisting of:

- Pentium 2 or equivalent processor running at least 400 cpu
- 128 Mb RAM or better, and a display capable of 32 bit (millions of colors)
- CD-player running at 30X or greater Flash 6, QuickTime 4, Internet Explorer 5, or Netscape Navigator 4, or later versions

**Printed Text Condition**

The printed text used was the *Applications Manual for the Revised NIOSH Lifting Equation* (Waters, Putz-Anderson, and Garg, 1994). This is a traditional style textbook with introductions, explanations, definitions, and sample problems. This text has been widely distributed as an instructional manual for the Revised NIOSH Lifting Equation.

**CD-ROM Training Condition**

The Revised NIOSH CD-ROM Lifting Equation training program is comprised of 4 lessons. Each lesson consists of several classes. Lessons one thru three are study lessons. Lesson 4 is a combined study follow-up and study evaluation lesson, and is interactive allowing choice and redesign of actual lifting scenarios so as to provide real world simulations.
Each class is made up of a series of screens with each screen consisting of a still or video depicting the material presented in that screen. Included in each screen is a written script which is also presented audibly. The written script has various “hot-words” which when clicked on presents relevant definitions. Most screens also have interactive quizzes with answers presented in real time. The instructional part of the CD-ROM (lessons 1, 2, and 3) contains a total of 137 Screens. Table 3 provides a summary of the lessons and classes.

<table>
<thead>
<tr>
<th>Table 3. – Summary of Classes and Lesson Content</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lesson 1: Introduction</strong></td>
</tr>
<tr>
<td>Class 1: Introduction to the Revised NIOSH Lifting Equation (19 Screens)</td>
</tr>
<tr>
<td>Class 2: Lifting Parameters and Variables (20 Screens)</td>
</tr>
<tr>
<td><strong>Lesson 2: Measurement</strong></td>
</tr>
<tr>
<td>Class 1: Single-Task Lifts (56 Screens)</td>
</tr>
<tr>
<td>Class 2: Lifts Requiring Significant Control (9 Screens)</td>
</tr>
<tr>
<td>Class 3: Multi-Task Lifts (15 Screens)</td>
</tr>
<tr>
<td><strong>Lesson 3: Redesigning Lifts</strong></td>
</tr>
<tr>
<td>Class 1: The Automatic Calculator and Redesign Strategies (18 Screens)</td>
</tr>
<tr>
<td><strong>Lesson 4: Follow-up Activities</strong></td>
</tr>
<tr>
<td>Sample Exercises (interactive simulations of lifting scenarios)</td>
</tr>
</tbody>
</table>

**Measurement Instruments**

Measurement instruments used are given in Table 4. All measurement instruments were in printed form.

<table>
<thead>
<tr>
<th>Table 4. – Measurement Instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-training Subject Background Evaluation</td>
</tr>
<tr>
<td>Subject Knowledge and Skills Evaluation</td>
</tr>
<tr>
<td>Technology Attitudes Evaluation</td>
</tr>
<tr>
<td>Self-Perception of Learning Evaluation</td>
</tr>
</tbody>
</table>

The pre-training and post-training written tests were used to assess changes in knowledge, and problem solving skills. The study researcher administered all tests and collected
them at their completion. The pre-training and post-training written knowledge and skills tests consisted of 32 multiple choice questions and 8 pictorial lifting scenarios requiring 16 choices (answers). Additionally, prior to the first training session, students filled out several questionnaires regarding their prior experiences with the lifting equation and e-learning technologies.

At the conclusion of the training, all subjects received the initial questionnaires plus several final written questionnaires and a test assessing their knowledge of and skills in using the Revised NIOSH Lifting Equation. The order of presentation in all conditions was to introduce the study, then to present and explain all informed consent materials. Next the pre-training questionnaires and test were administered and then, depending on study condition, either the study materials were distributed or instruction was given using the printed text or CD-ROM.

The subjects were allowed to take the materials home to study. A final visit time was set and at this time the subjects were re-administered the pre-study questionnaires and given post study questionnaires in addition to the post-study test. Subjects were allowed to keep all study materials (text and CD-ROM). A post study explanation period was held and any questions about the study were addressed.

**Measurement Instruments (Detailed Descriptions)**

There were six measurement instruments used in this study, although only two were selected for statistical analysis. The sixth was a Behavioral Observations Checklist which after the first few study runs was deemed as unnecessary but was included because it was subjectively evaluated (first few runs). All six measurement instruments were in written form. These measurement instruments are included in the appendix as attachments. The following sections describe each
of these instruments. A copy of all pre and post training materials, questionnaires and CD-ROM training program materials are included in the appendix as attachments. Instruments included:

- Pre-training Subject Background Evaluation
- Subject Knowledge and Skills Evaluation
- Technology Attitudes Evaluation
- Self-Perception of Learning Evaluation
- Behavioral Observations Checklist
- Subject Satisfaction Evaluation

A more detailed description of the purpose and administration for each instrument is as follows:

**Pre-training Subject Background Evaluation**

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Subject background knowledge of the Revised NIOSH Lifting Equation, knowledge of manual lifting tasks, and background computer experience. Written evaluation included five Likert-type items.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administration</td>
<td>The Subject Background Evaluation will be administered to all of the training groups. The evaluation will be administered before (pre-test) the training program. Evaluations will be administered and collected by the study researcher.</td>
</tr>
<tr>
<td>Purpose</td>
<td>The purpose of this evaluation is to collect information on the subjects’ previous knowledge of the Revised NIOSH Lifting Equation and manual lifting tasks, as well as with their previous computer experience. This may be used to interpret the impact of the training on their knowledge and skill gains, attitude changes, and training satisfaction.</td>
</tr>
<tr>
<td>Expected Outcomes</td>
<td>The expected outcome is that subjects having a greater knowledge and higher skills with respect to the Revised NIOSH Lifting Equation, knowledge of manual lifting tasks, and background computer experience. Written evaluation included five Likert-type items.</td>
</tr>
</tbody>
</table>
Equation, manual lifting tasks, and use of computer technology will have higher scores on posttests. This information may provide qualitative information on the background of the study subjects.

Subject Knowledge and Skills Evaluation

| Instrument | Subject knowledge is defined as the subject’s acquisition of information and skills. Knowledge gain will be measured using a thirty-two item multiple choice evaluation, and a 16 item real world still-life pictorial presentation of a person performing lifting tasks. This will be administered to all conditions. The subjects will be asked to evaluate and answer questions pertaining to a lifting task and the use of the lifting equation. This knowledge and skills Evaluation is designed to test for mastery in making the measurements required to correctly and accurately use the Revised NIOSH Lifting Equation. This evaluation addresses the content covered in the training program. Subjects are allowed a maximum of one hour to complete this evaluation. |
| Administration | The Subject Knowledge and Skills Evaluation will be administered to all subjects prior to training to establish a baseline score. It will be administered to all subjects again at completion of their training to test for change in their ability to correctly and accurately use the Revised NIOSH Lifting Equation. The content of the Subject Knowledge and Skills Evaluation used for all four learning conditions is identical because material presented is similar or identical. The pre-test and post-test evaluations consist of the same questions. At the completion of the post test training, the researcher/instructor will briefly cover the correct answers to the post-test knowledge evaluation. This will be done after the evaluations are collected by the study researcher, and the study |
The researcher will provide the subjects with immediate feedback regarding the correct post-test information.

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Comparisons of the pre-test and post-test responses to the Subject Knowledge and Skill Evaluation are done to provide information about changes in subject knowledge and skills that occurred as a result of training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Outcomes</td>
<td>There will be changes in subject knowledge and skills that occurred as a result of training. Of interest is whether the CD-ROM training provides affected the acquisition of knowledge and skills. It is expected that the CD-ROM training will produce higher post test scores.</td>
</tr>
</tbody>
</table>

**Technology Attitudes Evaluation**

<table>
<thead>
<tr>
<th><strong>Technology Attitudes Evaluation</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Instrument</strong></td>
</tr>
<tr>
<td><strong>Administration</strong></td>
</tr>
<tr>
<td><strong>Purpose</strong></td>
</tr>
<tr>
<td><strong>Expected Outcomes</strong></td>
</tr>
</tbody>
</table>
Self-Perception of Learning Evaluation

<table>
<thead>
<tr>
<th><strong>Self-Perception of Learning Evaluation</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Instrument</strong></td>
</tr>
<tr>
<td><strong>Administration</strong></td>
</tr>
<tr>
<td><strong>Purpose</strong></td>
</tr>
<tr>
<td><strong>Expected Outcomes</strong></td>
</tr>
</tbody>
</table>

Subject Satisfaction Evaluation

<table>
<thead>
<tr>
<th><strong>Subject Satisfaction Evaluation</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Instrument</strong></td>
</tr>
</tbody>
</table>
Subject Satisfaction Evaluations will be administered to all of the training groups. The Subject Satisfaction Evaluations will be administered with the post-test after the training program has been completed. Evaluations will be administered and collected by the researcher.

The purpose of this evaluation is to examine the strengths and weaknesses of each training approach. These will be evaluated using subject centered responses relating to the perceived adequacy of the training program (CD-ROM or written text), and (instructor or no-instructor). Subjects’ reactions to the Revised NIOSH Lifting Equation training program may provide information about modifications needed to improve training effectiveness.

The impact of CD-ROM training program will be a subjects’ feeling of having had a more satisfying learning experience than those of the subjects in the non-CD-ROM condition. There are no expectations as to what effect the addition of an instructor will have on this measure.

Behavioral Observation Checklist

A Behavioral Observation Checklist of the classroom environment and training will be completed by the study researcher for all training groups. Periodically, this checklist will also be completed by an independent observer. The university course instructor, if he/she chooses to remain in the classroom, will be given the opportunity to complete the checklist. The effect of situational (environmental) conditions such as seating, classroom size, lighting, acoustics, or subject-subject/subject-instructor interactions will be examined using this observational checklist. The checklist consist of six key areas on which an observer comments with respect to behaviors or problems and steps taken to correct these problems. The checklist was developed
based on prior literature employing such lists. (Laitinen, Marjamaki, & Paivarinta, 1999; Mattila, Rantanen, & Hyttinen, 1994, Ray, Bishop, & Wang, 1997).

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Checklist completed by the researcher, and periodically by an independent observer.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administration</td>
<td>The written checklist of behavioral observations was developed and field tested by the study researcher during the pilot study so as to establish the adequacy of the collected data. Behavioral observations will be conducted by the study researcher.</td>
</tr>
<tr>
<td>Purpose</td>
<td>Observations of classrooms provide information about variations in teaching methods (instructor conditions) and subject-technology interactions (CD-ROM) groups. It may also provide information about any other unexpected variations that could affect the overall learning environment.</td>
</tr>
<tr>
<td>Expected Outcomes</td>
<td>The impact of a problem-free learning environment is believed to be better knowledge and skills acquisition and retention. Subjects from a problem-free environment should also have a more satisfying learning experience. Observations of the classroom environment will be made noting any factors that influenced the effectiveness of the learning environment.</td>
</tr>
</tbody>
</table>

**Data Management**

The study researcher manually entered data into a database using excel statistical software. Subjects recorded their names on the evaluations, but coded numbers were used for individual data and corresponding sites for entry into the database. After completion of the data collection a key linking site codes to each specific classroom training site, as well as individual codes to specific subjects was created. Periodic checks were made to ensure the accuracy of the
entered data. A final independent researcher checked for correct data entry. At completion of the data collection, the key was destroyed. Master copies of the data set are preserved in locked hard copy files and on password protected electronic files according to current CDC/NIOSH requirements. Analysis was conducted on backup copies of the data set. Corrections to the data set were documented in a research log. Written evaluations and behavioral checklists (no identifiers) are being kept in a secured location. All data was archived at the conclusion of the study according to current CDC/NIOSH requirements.

**Methodological Limitations of Study**

It will still be difficult, if not impossible, to prevent university instructors in any of the training groups from providing anecdotal or casual examples that would amplify the content that was being discussed. University instructors may also have inadvertently commented about the learning mediums being used. There was no occurrence observed of any type of an extreme violation of study integrity such as text only students admitting to working with the CD-ROM. An independent researcher conducted several observations of selected training sessions and found no violations of study integrity. This researcher made every effort to be unobtrusive, but her presence may have influenced the behavior of both the instructors and the subjects. Following the training sessions, university instructors and subjects were briefly queried as to their impression of any adverse impact from the presence of the observer researcher. No adverse impact on study integrity was noted or found.

Limited resources and logistics prevented the study researcher from conducting observations of students assigned to self study learning. While these students could not discuss the material in their classes, it was impossible to prevent them from conferring outside of class.
As part of their debriefing, they were asked if they sought help with the material, how often, and from whom. This information aided in evaluating the effectiveness of either self study modality.

Some data was lost to students dropping a course. In particular, some post-evaluation opportunities were lost. Every effort was made to complete data collection in a timely manner ensuring maximum participation. Because of the unique characteristics of using university students, university instructors, and the university setting, generalizations to other occupational populations or contexts is limited. The findings from this study are best generalized to other samples drawn from universities or educational sectors. This was not perceived to be a problem, given the Revised NIOSH Lifting Equation is a tool meant to be used by select groups of target users (engineering and safety professionals). It is understood that the instruments used in this study are useful for other studies however in other types of training settings there may be alternative instruments that provide better evaluations of the impact of these types of training programs.

**Human Subject Concerns and Benefits from Study Participation**

The instructional interventions were conducted within existing training contexts (university classrooms). The subjects were required to attend the training sessions as a mandatory part of their course-work, but their participation in the pre-training and post-training evaluations was voluntary. Subject knowledge, attitude, and training satisfaction data were obtained through self administered written evaluations. Possible benefits that the subjects and university instructors received from their participation was an increased awareness of current and future training technologies, and increased awareness of safer lifting practices.

University instructors and subjects were allowed to keep the training materials they used (text or CD-ROM). All subjects were given copies of the CD-ROM and text. These were
distributed after the completion of the study so as to not contaminate the study subject pool. University instructors were provided with a copy of all the training materials, including CD-ROM and lifting text. This study did not present greater than a minimal risk of harm to the participants. Subject attendance in the training sessions was not a condition outside of the research context for which written consent would normally be required. In addition to the written informed consent form, subjects participating in the evaluations were provided with a fact sheet describing the parameters of the study. The fact sheet clearly stated that while the university required their attendance at training sessions, their participation in filling out the pre-training and post-training evaluations and questionnaires was entirely voluntary and they could withdraw from study participation at any time without penalty or prejudice.

Informed consent parameters were described orally and in writing at the beginning of both the pre-training and post-training evaluations, and were further discussed orally with all subjects as needed during the training. Furthermore, the study researcher verbally covered the points described in both the informed consent form and the fact sheet, and addressed any questions the subjects had. This was done before the start of the study and included the following statement: “You will be required to attend the training sessions as a mandatory part of your course-work, but your participation in the pre-training and post-training evaluations will be voluntary. You may withdraw your consent, refuse to participate, or end your participation in this study at any time without penalty or loss of course credits and grades to which you are otherwise entitled. If you choose not to fill out evaluations, you will be allowed to participate in the training portion of the study.”

Administration of the Informed Consent Form and Fact Sheet
All of the subjects were provided a copy of an informed consent form (to be signed by subject). All subjects received a fact sheet. The informed consent form had to be signed and returned to the researchers before a subject was allowed to participate in the study. All subjects were given a copy of the informed consent form and fact sheet to keep for their own records. The informed consent form and fact sheet are presented in the appendix as an attachment.

Information provided in the fact sheet includes:

- The purpose of this study.
- The duration and extent of their participation.
- The absence of risks or discomforts associated with evaluations.
- Their participation would have no bearing on their participation.
- Their participation is voluntary and may be discontinued at any time.
- Whom to contact with any questions about their rights as a participant in this study.
- Measures taken to ensure confidentiality of the data.
- When, where, and how they may obtain a summary of the study findings.

**Statistical Analysis**

A nonparametric test for multiple independent samples was used because the test variables are ordinal and the mean alone is not a valid estimate as the distances between the score values are arbitrary. By choosing nonparametric testing, even if the mean is valid but the distribution is non-normal, significant effects can still be determined and analyzed. A Kruskal-Wallis test for one way analysis of variance by ranks was chosen. It does not assume normality, and it can be used to analyze ordinal variables. The Kruskal-Wallis tests the null hypothesis that the groups do not differ in mean rank for a criterion variable (in this case correct performance on the post test).
The Median test was also conducted as this is another nonparametric method of evaluating data. The median method tests the null hypothesis that two or more independent samples have the same median, and assumes nothing about the distribution of the test variable. The median test is a chi-square test of independence between group membership and the proportion of cases above and below the median. Although nonparametric tests were used, the statistical power of the study was evaluated using Cohen’s formulas (Cohen, 1988). The rationale for the selection of sample sizes was based on the number of treatment variables, estimated number of subjects per training group, level of confidence, and estimations of the effect sizes produced by the training program. Power analyses were based upon calculations described by Cohen (1988, section 10.4, p. 514-530).
Chapter Three: Results

The independent variable was the instructional-format: CD-ROM with instructor (CI1), CD-ROM self study (CS2), printed text with instructor (TI), or printed text self study (TS2). The dependent variables were test scores on a written multiple choice test of knowledge and real world lifting simulations. All knowledge tests were hand scored. During scoring and prior to data analysis, all pre and post-tests were checked for data entry errors. All tests were scored twice: first by the primary researcher, and then by an independent scorer. These two scorers results were compared and discrepancies addressed. No discrepancies were noted. All scores were entered into a statistical program and were rechecked for accuracy. Subjects who did not complete all study requirements were not included in the statistical analysis.

Responses comparing the test outcomes across all four study conditions are summarized in Table 5. The maximum number of correct responses on the test was 48. The mean number of correct responses for the CD-ROM with an instructor was (30.35), for CD-ROM self study (22.65), for printed text with instructor (18.02), and printed text self study it was (14.05). The summary analyses revealed that subjects in the CD-ROM with instructor condition (CI) received higher test scores than subjects in the other three conditions. Summary analyses also revealed that subjects in the CD-ROM self study condition (CS) performed better than subject in both the printed text with instructor (TI) and the printed text self study (TS) conditions.

<table>
<thead>
<tr>
<th>Table 5. - Correct Responses: Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Condition</td>
</tr>
<tr>
<td>CD-Instructor (CI)</td>
</tr>
<tr>
<td>CD-Self (CS)</td>
</tr>
<tr>
<td>Text-Instructor (TI)</td>
</tr>
<tr>
<td>Text-Self (TS)</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>
As previously noted, nonparametric tests for multiple independent samples were used to investigate study data. These types of analyses were selected because the assumptions for parametric tests, such as analysis of variance, were not met. The test variable was ordinal, and the data did not meet requirements for the assumption of normality. Therefore, the mean and variance may not be informative data analysis measures. Both the chi-square (median) and the Kruskal-Wallis tests (mean rank) were conducted. Using the Kruskal-Wallis test, significant differences were found between the performances on the post-training knowledge and skills tests with the subjects in the CD-instructor (CI) group (mean rank=329.26) doing the best, participants in the CD-self study (CS) training group (mean rank=243.80) ranking second, text-instructor (TI) group (mean rank=163.56) ranking third, and text-self study (TS) group (mean rank=110.90) ranking last. Table 6 summarizes the ranking of groups based on posttest scores, and Table 7 summarizes the chi-square test statistics for the Kruskal-Wallis test. Tables 8 and 9 summarize median test frequencies and median tests chi-square statistics respectively.

<table>
<thead>
<tr>
<th>Treatment Condition</th>
<th>N</th>
<th>Mean Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD-Instructor (CI)</td>
<td>97</td>
<td>329.26</td>
</tr>
<tr>
<td>CD-Self (CS)</td>
<td>105</td>
<td>243.80</td>
</tr>
<tr>
<td>Text-Instructor (TI)</td>
<td>98</td>
<td>163.56</td>
</tr>
<tr>
<td>Text-Self (TS)</td>
<td>115</td>
<td>110.90</td>
</tr>
<tr>
<td>Total</td>
<td>415</td>
<td></td>
</tr>
</tbody>
</table>

Table 7. - Kruskal-Wallis Chi-Square Test Statistics

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-Square</td>
<td>197.51</td>
</tr>
<tr>
<td>df</td>
<td>3</td>
</tr>
<tr>
<td>Asymptotic Significance</td>
<td>.000</td>
</tr>
<tr>
<td>Monte Carlo Significance</td>
<td>.000</td>
</tr>
<tr>
<td>Significance 99% Confidence Lower Bound</td>
<td>.000</td>
</tr>
<tr>
<td>Significance 99% Confidence Upper Bound</td>
<td>.000</td>
</tr>
</tbody>
</table>
Table 8. - Frequencies by Training Condition

<table>
<thead>
<tr>
<th></th>
<th>Computer-Instructor</th>
<th>Computer-Self</th>
<th>Text-Instructor</th>
<th>Text-Self</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; Median</td>
<td>86</td>
<td>67</td>
<td>30</td>
<td>16</td>
</tr>
<tr>
<td>&lt; Median</td>
<td>11</td>
<td>38</td>
<td>68</td>
<td>99</td>
</tr>
</tbody>
</table>

Table 9. - Median Chi-Square Test Statistics

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
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With respect to the post-training knowledge and skills tests, significant differences were found between the CD-ROM and the Text groups. Subjects in the CD-instructor (CI) and CD-self study (CS) performed significantly better on the post training knowledge and skills test than subjects in the textbook-instructor (TI) and textbook self study (TS) groups.
Chapter Four: Discussion

Primary interest is whether self study, CD-ROM-based, computer delivered training can be effectively used as a substitute for a printed text, or a printed text with an instructor delivered training program. The purpose of this study was to investigate whether the CD-ROM by itself could effectively function as a replacement for the printed text, and specifically for the printed text with an instructor. Controversial issues exist as to the effectiveness of computer-assisted training versus instructor-delivered face-to-face training. This study’s findings that the computer-based, CD-ROM delivered training is as, or more effective than face-to-face instructor delivered training should help to quell this controversy. Also investigated was computer-delivered versus printed text delivered training. Of particular interest was the difficulty of conveying the information required to correctly and accurately use the Revised NIOSH Lifting Equation (RNLE).

The purpose of this study was not to reveal the ineffectiveness of the printed text in conveying information, but to evaluate the CD-ROM as a method to effectively convey the required knowledge to correctly and accurately use the RNLE. An examination of study generated data (subjects scores on the post study knowledge and skills test PSKST) revealed that the CD-ROM when used alone and without an instructor was significantly more effective than both the printed text by itself, and the printed text with an instructor. The CD-ROM with an instructor was significantly more effective than the CD-ROM when used by-itself. Performance on the PSKST was found to be best for the CD-ROM with instructor condition. This would be expected as the instructor is an “added value” to the already superior CD-ROM in conveying the knowledge and skills required to correctly and accurately use the RNLE.
There are other reasons why the CD-ROM might have been more effective in training and information delivery than the printed text. This study used college students who were more attuned to using computers. This may account for the CD-ROM self study subjects performing almost as well as the CD-ROM with instructor subjects. In fact, many subjects described the printed text as dry and uninteresting. Because of this, they might have studied less, or not read some parts of the printed text. Some subjects also liked the interactivity and animations that were a part of the CD-ROM training. The CD-ROM presented the material audio-visually, with an on screen quiz there-by allowing for immediate feedback with positive reinforcement for correct responses, and re-direction back to the training material for incorrect responses. Another advantage was the printed text was also included on the CD-ROM as a PDF file which could be accessed if needed.

An important aspect of the CD-ROM training was the interactivity of the training. The trainee is led screen-by-screen to solve a measurement problem, but if having difficulty, he/she can click back and forth to previous screens for immediate review or help. Although the printed text allowed for this review process, subjects negatively commented about problems, such as the pictures not being on the same page as the descriptive text explanations. Several subjects noted that because of text related problems, they just gave up and went to the next section of the printed text. Subjects liked the CD-ROM’s having all relevant information presented at one time and on one screen. Although there were several technological problems occurring during the study, such as damaged CD’s, computer lab access, and a crashed hardware problem, the overall subjective rating of the CD-ROM training program was excellent. The Pre-training Subject Background Evaluation, Technology Attitudes Evaluation, Self-Perception of Learning Evaluation and Subject Satisfaction Evaluation were not analyzed statistically. Subjective
review of the evaluations revealed that subjects overwhelmingly preferred the CD-ROM versus the printed text as a training tool.

I would normally be conservative and consider it misleading to interpret results as conclusive, but the statistical significance of the improvement of the CD-ROM training groups over both the printed text self-study and printed text with instructor-led groups is undeniable. The subjects’ performance on the post-training knowledge and skills test showed the CD-ROM-delivered training to be an effective method of training users to both correctly and accurately use the RNLE. This will allow training to be provided cost-effectively where-ever needed (both class and on site).
References


Russell, T. (1999). The No Significant Difference Phenomena: A Comparative Research Annotated Bibliography on Technology for Distance Education. International Distance Education Certification Center: Montgomery, AL.


### Appendix: Attachments

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Attachment 1 - Pre-Training Subject Background Evaluation

Pre-Training Subject Background Evaluation

1. I consider myself proficient in using computers.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

2. I have experience using CD-ROM-based software.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

3. I have had exposure to the NIOSH Lifting Equation.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

4. I have had exposure to safety concerns pertaining to manual lifting tasks.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

5. I consider my understanding of the NIOSH lifting equation to be:
   a. Good  b. Fair  c. Poor  d. No Knowledge
LESSON 1, CLASS 1:

Script for Voice Narration for Lesson 1, Class 1, Screen 1

In this lesson, you will learn what the Revised NIOSH Lifting Equation is, the types of lifts that are appropriate for using the Revised NIOSH Lifting Equation and the appropriate use of the Revised NIOSH Lifting Equation to evaluate and modify lifting tasks.

Script of Voice Narration for Lesson 1, Class 1, Screen 2

Lifting objects is a major cause of work-related low back pain and disability. Back pain and back injuries are one of the more common and costly types of work-related injuries, and place a heavy burden on workers’ compensation programs.

Script of Voice Narration for Lesson 1, Class 1, Screen 3

The Revised NIOSH Lifting Equation is one tool to prevent work related low back pain and disability.

Script of Voice Narration for Lesson 1, Class 1, Screen 4

The principal product of the Revised NIOSH Lifting Equation is the Recommended Weight Limit, or RWL, for a given set of lifting task conditions. The Recommended Weight Limit is the maximum weight that nearly all healthy workers can lift for up to 8 hours without increased risk of developing lifting-related low back pain (LBP). A healthy worker is a worker who is free of adverse health conditions that would increase the risk of a musculoskeletal injury. If the worker is not healthy, the RWL may need to be qualified by the worker’s health conditions.

Script of Voice Narration for Lesson 1, Class 1, Screen 5

The Revised NIOSH Lifting Equation can be used to calculate a Recommended Weight Limit appropriate for 90% of the healthy working population.

Script of Voice Narration for Lesson 1, Class 1, Screen 6

The Revised NIOSH Lifting Equation is not appropriate for non-lifting tasks such as holding, pushing, carrying, and walking or climbing with objects.

Script of Voice Narration for Lesson 1, Class 1, Screen 7

The Revised NIOSH Lifting Equation is only appropriate for lifting tasks in which the worker grasps an object with two hands and moves it vertically without mechanical assistance.
The Revised NIOSH Lifting Equation does not apply to one-handed lifts, lifting for more than eight hours, lifting while seated or kneeling, or lifting in a restricted work space where there are barriers in the way of the lift that obstruct the movement of the worker.

Script of Voice Narration for Lesson 1, Class 1, Screen 9

Certain working conditions prohibit the use of the Revised NIOSH Lifting Equation. The Revised NIOSH Lifting Equation does NOT apply where unpredictable conditions exist, such as unexpectedly heavy loads or slipping and falling hazards. The Revised NIOSH Lifting Equation does NOT apply when lifts are not smooth and continuous, such as when lifting unstable objects. The Revised NIOSH Lifting Equation does NOT apply to using high-speed body motions. The Revised NIOSH Lifting Equation does NOT apply when flooring conditions are slippery or otherwise do not provide good foot traction. The Revised NIOSH Lifting Equation does not apply under conditions of extreme cold, heat, or humidity.

Script of Voice Narration for Lesson 1, Class 1, Screen 10

The Revised NIOSH Lifting Equation cannot be used for certain types of lifts and lifting conditions. These lifts and lifting conditions place greater stress on the body. The same lifts and conditions that prohibit use of the Revised NIOSH Lifting Equation also increase the likelihood of injury. If the Revised NIOSH Lifting Equation cannot be used for one of these reasons, a potential hazard may exist.

Script of Voice Narration for Lesson 1, Class 1, Screen 11

The Revised NIOSH Lifting Equation is for basic lifting conditions, such as single-task lifting jobs in which the lifting task variables do not significantly vary from task to task, or only one task is of interest. Using the Revised NIOSH Lifting Equation for single-task lifts will be covered in Lesson 2.

Script of Voice Narration for Lesson 1, Class 1, Screen 12

The Revised NIOSH Lifting Equation may also be used for multi-task lifting jobs. In a multi-task lift, there are significant differences in task variables between tasks. For example, the shape or size of the objects may vary. The frequency of lifts may vary. If the worker is stacking items, the height of the destination can change as well.

Script of Voice Narration for Lesson 1, Class 1, Screen 13

Multi-task lifts are more difficult to analyze because each task must be analyzed separately. The Revised NIOSH Lifting Equation can accommodate up to 10 sets of task conditions per job. Using the Revised NIOSH Lifting Equation for multi-task lifts will be covered in Lesson 2.

Script of Voice Narration for Lesson 1, Class 1, Screen 14

The Revised NIOSH Lifting Equation may also be used for lifts that require precise placement of an object at its destination. A lift requires significant control if the worker must re-grasp the object to place it down carefully, hold the object momentarily before setting it down, position the
object carefully, or guide it into place. Using the Revised NIOSH Lifting Equation for lifts requiring significant control will be covered in Lesson 2.

Script of Voice Narration for Lesson 1, Class 1, Screen 15

The Revised NIOSH Lifting Equation was developed to help employers calculate the Recommended Weight Limit for a lifting task and to redesign jobs to make them safer. An equation is required to calculate the Recommended Weight Limit because there are many variables in lifting tasks. These variables will be identified and discussed in the next class.

Script of Voice Narration for Lesson 1, Class 1, Screen 16

A second measure for evaluating lifts, the Lifting Index, will be discussed in Lesson 2. The Lifting Index is useful for calculating the potential risk associated with a lifting task. The Lifting Index is the load weight (weight to be lifted) divided by the Recommended Weight Limit.

Script of Voice Narration for Lesson 1, Class 1, Screen 17

To analyze a lifting task, it is best to videotape the entire lifting sequence and view it in slow motion. This technique will help you identify where the greatest risks occur and where redesign is most feasible.

Script of Voice Narration for Lesson 1, Class 1, Screen 18

This training program contains an automatic calculator that converts measurements of each variable into the multipliers required to calculate the Recommended Weight Limit that is used to determine the Lifting Index. The calculator will be discussed in Lesson 3.

Script of Voice Narration for Lesson 1, Class 1, Screen 19

In this first class, we have introduced you to the Revised NIOSH Lifting Equation, Recommended Weight Limit, and Lifting Index. We have discussed when the Revised NIOSH Lifting Equation can and cannot be used, identified three basic lifting conditions that will be discussed further in Lesson 2, and informed you of the automatic calculator included with this program. The next class of this Lesson covers the lifting parameters and lifting variables used in the Revised NIOSH Lifting Equation.

LESSON 1, CLASS 2:

Script of Voice Narration for Lesson 1, Class 2, Screen 1

Before calculating a Recommended Weight Limit, you must understand several lifting parameters used to measure task variables that can be used to identify unsafe conditions. These variables include how far the worker’s arms must extend to lift-up or deposit the object, how high off the floor the worker’s hands are at the origin and destination of the lift, how well the worker can grasp the object, the degree of lifting off to the side of the body, and the number of lifts completed in a given period of time.
Script for Lesson 1, Class 2, Screen 2

To measure the lifting variables correctly, you must understand several parameters used in their measurements. There are eight lifting parameters: load weight, mid-ankle point, mid-knuckle point, point of projection, neutral body position, sagittal line, mid-sagittal plane and asymmetry line. Each of these parameters will be described in the next several screens.

Script of Voice Narration for Lesson 1, Class 2, Screen 3

To measure the weight of the object to be lifted, add the weight of the contents and the container. The combined weight of the contents and the container is called the load weight.

Script of Voice Narration for Lesson 1, Class 2, Screen 4

The mid-ankle point, or MAP, is the point midway between the inner ankle bones of the worker when lifting the object. For most lifting tasks, we are concerned with the mid-ankle point at the start, or origin of the lift. In a few lifting tasks, we will also need to consider the mid-ankle point at the destination of the lift.

Script of Voice Narration for Lesson 1, Class 2, Screen 5

The mid-knuckle point, or MKP, is the point midway between the worker's hands when holding the object. The mid-knuckle point must be located at the lift-off point for the lift. The lift-off point is the precise point when the object begins to move vertically. This point can vary in more complex lifting tasks, which will be covered in Lesson 2.

Script of Voice Narration for Lesson 1, Class 2, Screen 6

A neutral body position has the following features: the worker's body faces forward, the worker's hands extend in front of the body, and there is the least amount of twisting at the legs, torso, or shoulders. Deviation from a neutral body position during the lift increases the stress on the body.

Script for Lesson 1, Class 2, Screen 7

The point of projection, or POP, is an imaginary point on the floor directly below the mid-knuckle-point (MKP) at the start of the lift. To locate the POP, first locate the MKP and project this point straight downward to the floor. This point is the POP. Locating the POP is necessary to assess body stress from reaching and turning.

Script for Lesson 1, Class 2, Screen 8

The mid-sagittal plane divides the worker's body into right and left halves when in a neutral body position. When the worker lifts to either side of the mid-sagittal plane, body stress increases.

Script for Lesson 1, Class 2, Screen 9
The **sagittal line**, or SL, is an imaginary line on the floor at the base of the **sagittal plane**. Locating this line is necessary to assess body stress when lifting an object off to the side of the body.

**Script for Lesson 1, Class 2, Screen 10**

The asymmetry line is an imaginary line on the floor that connects the **mid-ankle point** to the **point of projection**. Like the **sagittal line**, the **asymmetry line** is used to assess body stress when lifting an object off to the side of the body.

**Script for Lesson 1, Class 2, Screen 11**

**Horizontal Location**, or H, is how far the **worker**'s arms extend when lifting or placing the object.

**Vertical Location**, or V, is the height of the hands above the floor, measured from the floor to the midpoint between the hand grasps, as defined by the large middle knuckle (MKP).

**Vertical Travel Distance**, or D, is the absolute value of the difference between the vertical heights at the destination and origin of the lift. Vertical travel distance is how far vertically up or down the object is moved from the beginning to the destination of the lift.

**The Angle of Asymmetry**, or A, is how far the object is lifted off to the side of the body.

**The Frequency of Lifts**, or F, is the number of lifts performed per minute averaged over a representative 15 minute time period.

The **Duration of Lifting** is either short (less than 1 hour), moderate (1-2 hours), or long (2-8 hours).

**Coupling Classification**, or C, is the quality of the worker's grasp on the object and is rated as good, fair, or poor.

These seven **variables** influence the amount of stress on a worker's body while lifting. The **Revised NIOSH Lifting Equation** uses these **variables** to calculate the **Recommended Weight Limit** used in the Lifting Equation.

**Script for Lesson 1, Class 2, Screen 12**

The **horizontal location variable**, or H, is the measured distance between the **mid-ankle point** and the **point of projection**. The **horizontal location** is measured at the lift-off point, which is the precise point when the object begins to move vertically or the weight of the object is supported by the worker.

**Script for Lesson 1, Class 2, Screen 13**

The **vertical location** variable, or V, is the vertical height of the hands above the floor. **Vertical location** is measured at both the origin and destination of the lift. **Vertical location** is the vertical distance between the **point of projection** (POP), which is a point on the floor directly below the
mid-knuckle point (MKP), and the vertical height of the hands measured at the mid-knuckle point.

Script for Lesson 1, Class 2, Screen 14

Vertical Travel Distance variable, or D, is the absolute value of the difference between the vertical heights at the destination and origin of the lift. Vertical travel distance is how far vertically up or down the object is moved from the beginning to the destination of the lift.

The vertical travel distance variable is the measured difference between the vertical location at the origin of the lift and the vertical location at the destination of the lift.

Script for Lesson 1, Class 2, Screen 15

The Angle of Asymmetry variable, or A, is the measured angle between the sagittal line and the asymmetry line when the worker is lifting off to the side of the body.

Script for Lesson 1, Class 2, Screen 16

The Lifting Frequency variable, or F, refers to the average number of lifts performed per minute. To calculate lifting frequency, count the number of lifts completed by the worker in a 15-minute period of time, then divide the total by 15 to get the number of lifts per minute. The 15 minute period used for averaging should be representative of the duration of the lifting task. In the Revised NIOSH Lifting Equation, the duration is either short (less than 1 hour), moderate (1-2 hours), or long (2-8 hours). The Revised NIOSH Lifting Equation is not used for durations longer than 8 hours.

Script for Lesson 1, Class 2, Screen 17

Coupling Classification variable, or C, refers to how well the worker can grasp the object. If there are handles or hand-hold indentations, the grasp is considered good. If the worker can easily get his or her fingers under the object, the grasp is fair. If a good or fair grasp is not possible, the grasp is poor.

Script for Lesson 1, Class 2, Screen 18

When measuring the lifting variables (H, V, A, etc.), it is important to identify the actual “lift-off” point for the lift. The lift-off point is defined as the point where the object first begins to move vertically or the weight of the object is supported by the worker. This should not be confused with the point where it first begins to move laterally. For example, when a worker lifts an object from a counter, he or she may slide or pull the object laterally toward his or her body before actually beginning to lift or lower the object vertically. In this case, the variables are measured at the point where the object (load) begins to move vertically rather than the point where the object began to move laterally.

Another example would be a lift in which the worker slides, pushes or pulls an object laterally off a counter and as the object completely clears the counter the weight of the object is supported by the worker.
When either of these conditions occurs, the horizontal location (H) and the angle of asymmetry (A) measurements may both be different than if the measurements were made when the object began to move laterally. In either case, the point where the weight of the object is supported by the worker is the lift-off point and is the starting point of the lift.

Script for Lesson 1, Class 2, Screen 19

The horizontal Location (H) is the distance the worker’s hands extend out from the body. The farther the worker’s arms extend, the greater the stress on the body. When calculating horizontal location (H), the distance will be different if both feet are not planted on the ground. The worker may lean forward with the weight bearing on only one foot. The worker’s other foot may be raised or slightly touching the ground so as to act as a counter-balance. In either case, the total weight of the lift is supported by only the one foot. The horizontal component (H) is measured from directly below the weight bearing foot. This will result in a different horizontal location (H) than if the worker has both feet firmly planted on the ground.

In summary, two points are needed to measure horizontal location (H): 1) the point projected on the floor directly below the midpoint of the hand grasps (load center), and 2) the point measured from directly below the weight bearing foot if leaning forward on one foot, or from the midpoint of the line joining the inner ankle bones (MAP) if both feet are weight bearing. It is important to accurately assess whether the weight of the object being lifted is supported with one or both feet. Whether or not the worker is supporting the weight with one or both feet may make a difference in horizontal location (distance) and consequently a difference in the horizontal multiplier coefficient used in the lifting equation.

Script for Lesson 1, Class 2, Screen 20

The lifting parameters introduced in this lesson: (point of projection, mid-ankle point, mid-knuckle point, sagittal line, and asymmetry line) are used to measure the seven different lifting variables: (horizontal location, vertical location, vertical travel distance, angle of asymmetry, lifting frequency, duration of lifting, and the coupling classification) which are used to calculate a Recommended Weight Limit with the Revised NIOSH Lifting Equation. To calculate a Recommended Weight Limit accurately, you must understand each parameter and variable, and how they are converted into the multipliers used by the Revised NIOSH Lifting Equation to compute the Recommended Weight Limit. The table identifies the parameters used to measure each variable. For example, the mid-knuckle point, or MKP, is used in the measurement of every variable. The table also indicates that variable A, the angle of asymmetry, may be the most difficult to measure since it involves all the parameters. In Lesson 2, we will demonstrate how to measure each lifting task variable accurately using the lifting parameters.

LESSON 2, CLASS 1:

Script for Lesson 2, Class 1, Screen 1

The Revised NIOSH Lifting Equation can be used to calculate a Recommended Weight Limit for single-task lifts, which will be discussed in this class; lifts requiring significant control, which will be discussed in the second class of this lesson; and for multi-task lifts, which will be discussed in the third class of this lesson.
Script for Lesson 2, Class 1, Screen 2

In a single-task lifting job, the lifting task variables do not significantly vary from task to task, or only one task is of interest.

Script Narration for Lesson 2, Class 1, Screen 3

To use the Revised NIOSH Lifting Equation for single-task lifting jobs, you must accurately measure each of the following seven variables.

**Horizontal Location**, or H, is how far the worker's arms extend when lifting or placing the object measured from the mid-point of the line joining the inner ankle bones (MAP) to a point projected on the floor directly below the mid-point of the hand grasps (MKP, and load center).

**Vertical Location**, or V, is the height of the hands above the floor, measured from the floor to the midpoint between the hand grasps as defined by the large middle knuckle (MKP).

**Vertical Travel Distance**, or D, is the absolute value of the difference between the vertical heights at the destination and origin of the lift. Vertical travel distance is how far vertically (up or down) the object is moved from the beginning to the destination of the lift. D is the measured difference between the vertical location, or V, at the beginning of the lift and the vertical location at the destination of the lift.

**The Angle of Asymmetry**, or A, is how far the object is lifted off to the side of the body.

**The Frequency of Lifts**, or F, is the number of lifts performed per minute averaged over a representative 15 minute time period.

The **Duration of lifting** is either short (less than 1 hour), moderate (1-2 hours), or long (2-8 hours).

**Coupling Classification**, or C, is the quality of the worker's grasp on the object and is rated as good, fair, or poor.

In this class, you will learn how to accurately measure each of these variables.

Script for Lesson 2, Class 1, Screen 4

As we discuss how to measure the variables, you will be shown how to input these measurements into the automatic calculator. This way, you will learn how to use this powerful tool as you learn how to measure the variables themselves. The automatic calculator can accept measurements in pounds and inches (English) or kilograms and centimeters (Metric).

Script Narration for Lesson 2, Class 1, Screen 5

**Horizontal Location**, or H, is the distance (how far) the worker's arms extend (measured from the hands), when lifting or placing an object. H is measured from the mid-point of the line joining the inner ankle bones (MAP) to a point projected on the floor directly below the mid-point of the
hand grasps (MKP, and load center). The farther the worker’s arms extend, the greater the stress on the body when lifting.

**Script for Lesson 2, Class 1, Screen 6**

To measure the Horizontal Location for single-task lifts without significant control, begin at the mid-ankle point at the start of the lift (lift off point).

**Script for Lesson 2, Class 1, Screen 7**

The final point required for measuring the Horizontal Location for single-task lifts without significant control is the point on the floor directly below the mid-knuckle point when the worker reaches out to lift the object (lift off point). This point is called the point of projection (POP).

**Script for Lesson 2, Class 1, Screen 8**

The measurement for the Horizontal Location is the horizontal distance between the mid-ankle point and point of projection. The Horizontal Location is measured at the lift-off point, which is the precise point when the object begins to move vertically, or the weight of the object is supported by the worker. Enter the horizontal location measurements into the automatic calculator.

**Script for Lesson 2, Class 1, Screen 9**

The vertical location, or V, is the height of the worker’s hands above the floor when grasping the object. A vertical location that is about waist-high is least likely to stress the body. The more the worker has to bend lower or reach higher, the greater the stress on the body. The Revised NIOSH Lifting Equation requires that the vertical location be measured at both the start and destination of the lift.

**Script for Lesson 2, Class 1, Screen 10**

To measure the vertical locations for a lift, locate the mid-knuckle point between the worker’s hands when grasping the object at the beginning of the lift (lift off point) and at the destination of the lift. The mid-knuckle point is a required point for measuring the vertical location.

**Script for Lesson 2, Class 1, Screen 11**

The point on the floor directly below the mid-knuckle point is the point of projection. This point must be located at the beginning of the lift (lift off point) and at the destination of the lift, to correctly measure the vertical locations for the lift.

**Script for Lesson 2, Class 1, Screen 12**

Vertical Location, or V, is the vertical height of the hands above the floor measured at the origin and destination of the lift. Vertical location is the vertical distance between the point of projection (POP), which is a point on the floor directly below the mid-knuckle point (MKP), and the vertical height of the hands measured at the mid-knuckle point.
Once you have measured the **Vertical Location** (V) at the start and destination of the lift, place the two values into the **automatic calculator**. The data-entry boxes are highlighted on the screen.

**Vertical Travel Distance**, or D, is the absolute value of the difference between the vertical heights at the destination and origin of the lift. Vertical travel distance is how far vertically (up or down) the object is moved from the beginning to the destination of the lift. The vertical travel **distance variable** is the measured difference between the **vertical location**, or V, at the beginning of the lift and the **vertical location** at the destination of the lift. When this difference is small, the lift puts less stress on the body, than a lift where a **worker** must move the object vertically (up or down) a greater distance.

To measure the vertical travel distance, first determine the **vertical location** at the beginning of the lift.

Now find the **vertical location** at the destination of the lift.

Now you are ready to find the vertical travel distance. The absolute value of the difference between the **vertical location** at the start of the lift (lift off point) and the **vertical location** at the destination of the lift is the vertical travel distance.

The vertical travel distance, or D, is automatically calculated when the **vertical location** at the start of the lift and the **vertical location** at the destination of the lift are entered into the correct data fields of the **automatic calculator**. Note that the value for D is assumed to be at least 10 inches (25cm), and the automatic calculator will display a default value of 10 inches (25cm) for a D of 10 inches (25cm) or less.

The **angle of asymmetry**, or A, is the angle at which a **worker** lifts off to the side of the body. It is the measured angle between the **sagittal line** and **asymmetry line** when lifting off to the side of the body.
The **sagittal line** is the line (projected on the floor) passing through the mid-point between the inner ankle bones and lying in the **mid-sagittal plane**, as defined by the **neutral body position** (i.e., hands directly in front of the body, with no twisting at the legs, torso, or shoulders). To measure the **angle of asymmetry**, first locate the **sagittal line**.

**Script for Lesson 2, Class 1, Screen 21**

Next, determine the point of **projection (POP)** for the lift. Recall, the POP is the point on the floor directly below the MKP. If the lift is off to the side of the body, a second line, the **asymmetry line**, must also be located. The asymmetry line is the horizontal line that joins the mid-point between the inner ankle bones (MAP) and the point projected on the floor (POP) directly below the mid-point of the hand grasps as defined by the large middle knuckles (MKP). Remember to take the lift-off point into consideration when determining the point of projection.

**Script for Lesson 2, Class 1, Screen 22**

Use a protractor to measure the angle between the sagittal and asymmetry lines. Your result will be the **angle of asymmetry**.

**Script for Lesson 2, Class 1, Screen 23**

You must always measure A at the origin of the lift. If **significant control** is required, you must also measure A at the destination of the lift. There are two data entry boxes for A. If the worker lifts off to the side of the body at the beginning of the lift, use the box on the left. If **significant control** is required and the worker sets the object down off to the side of the body at the destination of the lift, use the box on the right. In any case where **significant control** is required, you must check to confirm that the significant control box is selected on the **automatic calculator**. Remember, where **significant control** is required you must also measure H at both the origin and the destination of the lift.

**Script for Lesson 2, Class 1, Screen 24**

The Lifting Frequency variable, or F, refers to the average number of lifts performed per minute. To calculate lifting frequency, count the lifts completed by the **worker** in a 15-minute period of time, and then divide the total by 15 to get the average number of lifts per minute. The 15 minute time period used for averaging should be representative of the duration of the lifting task.

**Script for Lesson 2, Class 1, Screen 25**

To begin the frequency count, select a fifteen-minute segment of lifting in a work shift and count the number of lifts during that period. The entire duration of the lifting task may have to be examined to determine the correct 15 minute segment which should be used to calculate the frequency. The segment to be sampled should be representative of the conditions that occur most often in the task.
To accurately count the number of lifts, you may want to videotape the worker and use a counter.

**Script for Lesson 2, Class 1, Screen 27**

To find the frequency, divide the total number of lifts measured over a representative 15 minute time period by 15. This is the average number of lifts per minute for the lifting task.

**Script for Lesson 2, Class 1, Screen 28**

Place your result in the data entry box for variable F. The automatic calculator does not automatically divide the total number of lifts measured over a representative 15 minute time period by 15 when the total is entered into the data box for variable F. You must do this calculation, and then enter the results into the data box for variable F.

**Script for Lesson 2, Class 1, Screen 29**

The duration of the overall lifting task also affects the degree of stress on the body. The automatic calculator accommodates three spans of continuous lifting: (short) less than 1 hour, (moderate) 1 to 2 hours, and (long) 2 to 8 hours. Select one of these options.

**Script for Lesson 2, Class 1, Screen 30**

To select the correct duration option —less than 1 hour, 1 to 2 hours, or 2 to 8 hours— it is necessary to measure any recovery times the worker receives. If these recovery times are adequate, they can reduce stress on the body. Recovery time is defined as any period where lifting is not performed. This may include doing light-work activities such as monitoring operations, eating lunch, or resting.

**Script for Lesson 2, Class 1, Screen 31**

There are three general rules for selecting the correct duration option. For continuous lifting periods of 1 hour or less, an equal amount of recovery time is required to reduce the stress on the worker’s body. If the required recovery time is not met, and a subsequent lifting session is required, then the total lifting times must be combined to correctly determine the duration category.

For continuous lifting periods of 1 to 2 hours, a recovery time that is at least 30% of the lifting period is required. For example, if the worker lifts for 90 minutes, he or she will need at least 27 minutes of rest. If the recovery time requirement is not met, and a subsequent lifting session is required, then the total work times must be used to correctly determine the duration category.

For any continuous lifting period longer than 2 hours, select the 2 to 8 hour duration category. This lifting duration category requires standard industrial rest breaks (e.g., morning, lunch, and afternoon).

**Script for Lesson 2, Class 1, Screen 32**
The **Coupling Classification**, or C, is a rating of the worker’s grasp on an object. The quality of the grasp is rated good, fair, or poor. A poor grasp places more stress on the worker than one that is fair or good.

**Script for Lesson 2, Class 1, Screen 33**

Classifying a hand grasp as good, fair or poor depends on three lifting condition **variables**: the position of the worker’s hands when he or she grasps the object at the beginning of the lift; the object’s shape, surface consistency, and size; and the presence of handles or cut-out hand-holds on the object. The effectiveness of the coupling is not static, but can vary throughout a lift. The entire range of the lift should be considered when classifying hand-to-object couplings. If there is any doubt about classifying a particular coupling design, the more stressful classification should be selected.

**Script for Lesson 2, Class 1, Screen 34**

In a good hand grasp, the object has handles or cut-out hand-holds that permit the worker to curl the fingers on both hands for a firm grasp. The grasp is considered good so long as the worker can hold the object with his fingers curled around the object or handles.

**Script for Lesson 2, Class 1, Screen 35**

A hand grasp is considered fair under any of the following conditions: the object to be lifted is held from underneath with the fingers and palms at an angle of about 90 degrees; the object may have handles or hand-hold cut-outs of less than optimal design; or the object may have hand-hold cut-outs which are typically not used for lifting.

**Script for Lesson 2, Class 1, Screen 36**

A hand grasp is considered poor under any of the following conditions: the object is bulky, awkward, or has sharp edges; the worker must wear gloves; or the worker must squeeze the object between the hands, or hold the object in a way which makes it impossible to curl the fingers.

**Script for Lesson 2, Class 1, Screen 37**

The best coupling is attained when the object has handles or hand-holds of optimal design, is not bulky or otherwise difficult to hold, and has no sharp edges. If the worker’s hands use different couplings on the object, the coupling classification should be based on the most stressful coupling required throughout the lift. The entire range of the lift should be considered when classifying hand-to-object couplings.

**Script for Lesson 2, Class 1, Screen 38**

When using the **automatic calculator**, simply check whether the hand grasp is good, fair, or poor.

**Script for Lesson 2, Class 1, Screen 39**
Once the values for all seven variables and the load weight are entered into the automatic calculator’s data entry fields, a Recommended Weight Limit is calculated automatically. This is the Recommended Weight Limit that nearly all healthy workers could perform for the work conditions selected.

Script for Lesson 2, Class 1, Screen 40

Now that you know what measurements are required to correctly use the Lifting Equation, let’s try for a deeper understanding of the equation itself?

Based on research, NIOSH has determined that 51 pounds is the maximum recommended weight that all healthy workers should lift under ideal conditions. This value is known as the load constant, or LC.

Script for Lesson 2, Class 1, Screen 41

The Revised NIOSH Lifting Equation is used to adjust the load constant of 51 pounds for less-than-ideal lifting conditions. In the equation, each of the variables we have discussed converts to a multiplier. A multiplier of 1 across all six variables would make the Recommended Weight Limit (RWL) equal to the load constant of 51 pounds. This would be indicative of an ideal lifting condition. The calculations required to compute the RWL may appear complex, but it is important to remember that the automatic calculator does these calculations for you. All you are required to do is input the correct measurements for each variable into the automatic calculator. However, because you may find it useful to make calculations on your own, we will discuss the specific multipliers next.

Script for Lesson 2, Class 1, Screen 42

Under ideal lifting conditions, the multiplier for each variable is 1. Under less-than-ideal conditions, the multipliers are less than 1, which reduces the Recommended Weight Limit.

Script for Lesson 2, Class 1, Screen 43

Six of the seven variables: H, V, D, A, F, and C, convert to a multiplier: HM, VM, DM, AM, FM, and CM respectively. There is an eighth factor, the load constant (LC), which always equals 51 pounds. When you place all the multipliers in the equation, and complete the calculations you will have computed the Recommended Weight Limit.

There are two ways to manually convert the variables to numeric multipliers (coefficients): the conversion formulas and conversion tables. However, using the automatic calculator is recommended, both for ease of use, and accuracy of results.

Script for Lesson 2, Class 1, Screen 44

When using the calculator, enter the measurements for each variable at the beginning of the lift in the designated spaces. For lifts requiring significant control, measurements at the destination of the lift will also be required—we will discuss significant control in the next class. Once all the measurements are entered, the Recommended Weight Limit is calculated automatically.
Let’s look at an example of the Revised NIOSH Lifting Equation in action from start to finish. All calculations will be to three decimal places.

The load constant, or LC, is always 51.000 pounds, although the actual weight lifted for this example is 35.000 pounds.

The first measurement is the horizontal location, or H, which is 20 inches. This converts to a horizontal multiplier of .500. When you use the calculator, conversions are done automatically. You can also use the conversion formulas or the conversion tables to determine the multipliers.

The measured vertical location at the origin of the lift, or V, is 15 inches, which converts to a vertical multiplier of .888.

The vertical travel distance, or D, is the distance between V at the origin of the lift, which in this example is 15 inches, and V at the destination of the lift, which is 50 inches. Therefore, D is 35 inches, which converts to a distance multiplier of .871.

The angle of asymmetry, or A, is 45 degrees, which converts to an asymmetric multiplier of .856.

The lifting frequency, or F, is 1 lift per minute and the duration category in this example is 1 hour, which converts to a frequency multiplier of .940.

Lastly, the coupling classification, or C, is considered poor because the worker must squeeze the object between his hands. This rating converts to a coupling multiplier of .900.

Given these measurements, the automatic calculator constructs the following equation: 51.000 x .500 x .888 x .871 x .856 x .940 x .900, equals 14.282. The Recommended Weight Limit for this example is 14.282 pounds, which can be further rounded to 14.3 pounds.

The multipliers with the lowest values suggest which variables can be modified to make the lift safer.

To determine the relative physical demand for the job you will need to calculate the Lifting Index, or LI. The Lifting Index is calculated by comparing the Recommended Weight Limit to the actual load weight.

The Lifting Index (LI) provides an estimate of the relative magnitude of physical stress associated with a particular manual lifting task. The Lifting Index is a numerical estimate of physical stress and is calculated by dividing the weight of the load lifted by the RWL. Consider the previous example, the RWL was 14.3 pounds, and the weight being lifted (load weight) was 35 pounds. The LI is equal to 35.0 divided by 14.3 or 2.45.
Companies can use the Lifting Index to design safer lifts and reduce the chance of injury to workers.

In summary, the product of the Revised NIOSH Lifting Equation is the Recommended Weight Limit (RWL). The RWL is used to calculate a Lifting Index (LI) value. The LI is a numerical value that provides a relative estimate of the level of physical stress associated with a particular manual lifting task. To calculate the Lifting Index, divide the actual weight lifted (load weight) by the Recommended Weight Limit. Remember that load weight is the weight of the object plus the weight of the container.

A Lifting Index of 1 means the load weight equals the RWL. Values greater than 1 mean the load weight exceeds the RWL, indicating increased stress on the worker. The greater the Lifting Index, the fewer the number of workers who will be able to perform the lifting task safely. A Lifting Index between 1 and 2 means there is increased risk of lower back pain for some workers. Such jobs should be redesigned if feasible. If the Lifting Index is greater than 2, it is highly recommended that the lift be redesigned.

The Lifting Index allows safety personnel to compare different job designs. The lifting task with the lowest Lifting Index is the least likely to result in lifting-related back injury.

LI values for different lifts can be used to prioritize hazardous lifts that need to be redesigned. That is, the lift with the highest LI should be redesigned first.

When the LI is greater than 1, look for ways to make the lift safer. Typically, one or more of the lifting variables can be modified to change the RWL, which may lower the LI. As a rule of thumb, begin by modifying the variable with the lowest individual multiplier value. Then proceed to other variables if necessary. You may have to modify several variables to lower the LI to an acceptable value.

If you find that certain lifting variables cannot be changed, concentrate on those you can change. Remember that your goal is to lower the LI as much as feasible. Strategies for redesigning hazardous lifting jobs are discussed in Lesson 3.
If we use the Recommended Weight Limit of 14.3 pounds from our previous example, and using a load weight of 35 pounds, we would get a Lifting Index of 2.45. The Lifting Index is calculated by dividing the load weight (35 pounds) by the Recommended Weight Limit (14.3 pounds). A Lifting Index between 2 and 3 indicates an increased risk of injury. Based on the LI of 2.45, this lifting job should be redesigned if possible.

In this class, we discussed how to measure the seven variables used in the Revised NIOSH Lifting Equation. We only looked at single task lifts, defined as lifts in which the task variables do not significantly vary from task to task, or only one task is of interest. We also discussed how to use the automatic calculator to determine Recommended Weight Limits and a Lifting Index for these lifts.

In the next class, we will apply this same information to lifts that require the worker to maintain significant control of the object when it is deposited.

The final class in this lesson will discuss multi-task lifting jobs, which are defined as jobs in which there are significant differences in task variables between tasks.

LESSON 2, CLASS 2:

When an object must be placed in a precise position at the destination of the lift, the stress on the body may be greater than at the beginning of the lift. Precise placement requires significant control and may create more stress on the body than the act of lifting itself. Therefore, determining Recommended Weight Limits for lifts requiring significant control is more complex.

Significant control is usually required when a worker must re-grasp, momentarily hold, or carefully position the object near or at the destination of the lift. These circumstances require the worker to slow the motion of the lift, which applies significant upward force on the body. Depending on the velocity of the lift, this deceleration force can be as great as the force required to lift the object at the origin of the lift.

For lifts requiring significant control, Recommended Weight Limits must be calculated at both the origin and destination of the lift. The lower of the two RWL’s is used to assess the lift.

If a load is difficult to handle, the worker may have to reposition his hands during the lift in order to maintain control. This condition often occurs when the load is oddly shaped or if the contents shift during the lift. Either of these conditions will require the worker to use significant control.
**Script Narration for Lesson 2, Class 2, Screen 5**

*Significant control* may be required when the load is fragile and requires careful handling. This is because a large deceleration force may be required to carefully place the object at the destination of the lift.

**Script Narration for Lesson 2, Class 2, Screen 6**

The stress on the body increases if the *worker* must carefully position or otherwise guide the object at the destination of the lift. If the lifting job requires significant control, the lifting job should be thoroughly evaluated to determine why *significant control* is needed. The lifting job may need to be redesigned to eliminate the need for *significant control*. The lifting job may be structured so that significant control cannot be eliminated, in which case we must calculate *Recommended Weight Limits* for both the beginning and destination of the lifting task.

**Script Narration for Lesson 2, Class 2, Screen 7**

Lifts requiring *significant control* can place increased stress on the *worker* and because of their complexity, can be difficult to assess and redesign. Because of this, we will review *significant control*. For lifts involving significant control, the *Recommended Weight Limit* must be calculated at the beginning and at the destination of the lift. *Significant control* is required when the *worker* must reposition his hands, momentarily hold the object, reposition the object, or guide the object at the destination of the lift.

**Script Narration for Lesson 2, Class 2, Screen 8**

After an *RWL* is calculated for the beginning of the lift and a second RWL is calculated for the destination of the lift, the lowest value is used since it provides the most protection for the *worker*.

**Script Narration for Lesson 2, Class 2, Screen 9**

When an object is fragile, awkward to handle, or must be precisely located, the *worker* will have to exercise *significant control*. The *worker* may have to change his grasp, slow or alter his or her movement, or otherwise interrupt the fluid motion of the lift. All such conditions place additional strain on the body. If these conditions require significant control, *RWL’s* must be calculated for the beginning and destination of the lift. The lowest *RWL* is used to determine the safest lifting conditions.

**LESSON 2, CLASS 3:**

**Script Narration for Lesson 2, Class 3, Screen 1**

Some jobs involve a series of different tasks. Each task may have discrete characteristics. These jobs may consist of tasks in which there are significant differences in task *variables* between tasks. These jobs are called *multi-task lifting*.
**jobs.** An example of a multi-task lifting job is a worker loading cartons from a pallet onto a conveyor. The cartons are vertically stacked from the floor in five tiers. This job is divided into five tasks representing the five tiers of loaded pallets, with each tier being a distinct lifting task, which when combined make-up the multi-task job of off-loading the cartons from the pallet onto the conveyor.

**Script Narration for Lesson 2, Class 3, Screen 2**

To correctly identify and analyze each task in a multi-task lifting job, you may want to videotape the entire lifting sequence and view it in slow motion. In this way you can see the differences in task variables and assess the overall lifting job.

**Script Narration for Lesson 2, Class 3, Screen 3**

Some Multi-Task Lifting jobs require significant control at the completion of one or more tasks of the multi-task lift. Just as with single-task lifts, Recommended Weight Limits for each significant control condition must be calculated at the beginning and destination of the lift. In the case of Multi-Task Lifting Jobs you might have to calculate Recommended Weight Limits for each significant control condition, where each component task of the multi-task lift by itself requires significant control.

**Script for Lesson 2, Class 3, Screen 4**

Because of the complexity of the calculations required by multi-task lifting jobs, it is best to use the automatic calculator whenever possible. The automatic calculator can accommodate a Multi-Task Lifting job consisting of up to 5 separate lifting tasks.

**Script Narration for Lesson 2, Class 3, Screen 5**

In Multi-Task Lifting Jobs the characteristics of individual lifts within the same job are different. The individual lifts can be grouped into a small set of separate single-task lifts that can be analyzed using a multi-task approach. The previous example of a multi-task job included palletizing or de-palletizing, in which the vertical height of the lift was determined by the vertical height of the row in the stack. Other examples of multi-task jobs are sequential jobs such as machining or assembly operations in which multiple parts are lifted in a predictable sequence, and packing operations in which individual items are packed into a box before the box itself is lifted.

**Script Narration for Lesson 2, Class 3, Screen 6**

Multi-task jobs are more difficult to evaluate because they involve more data. Using the multi-task approach, the task characteristics are measured for each single-task component lift. A formula is then used to calculate the Recommended Weight Limit for the multi-task job, and this is used to calculate a Composite Lifting Index (CLI). Remember, the LI represents the relative estimate of physical stress associated with a particular manual lifting task, whereas the CLI represents the collective physical demands (stress) associated with the overall multi-task job.
The analysis of each separate component lift is similar to the analysis of single-task lifts discussed earlier. As with single-task lifts, you must determine whether significant control is needed. This must be done with each component lift of the multi-task lifting job. Using the Automatic Calculator, the multi-task approach is appropriate for multi-task lifting jobs consisting of up to 5 separate component single-task lifts. If the multi-task lifting job consists of more than 5 component lifts, the variability is too great to use the automatic calculator. (However, the Revised NIOSH Lifting Equation itself can accommodate a multi-task job with up to 10 separate component single-task lifts.

Script Narration for Lesson 2, Class 3, Screen 7

To identify each component task and calculate a Recommended Weight Limit for multi-task jobs, you may want to videotape the entire lifting sequence and conduct a job analysis. You will need to understand the Recommended Weight Limit, the Lifting Index, and a few special calculations specific to multi-task lifting jobs. You will also need to become familiar with the expanded data entry fields in the automatic calculator.

The next several screens describe the special calculations used to determine the Recommended Weight Limit for multi-task lifting jobs. If you are not using the automatic calculator, you must know these intermediate calculations in detail to determine the RWL, and the CLI. If the automatic calculator is used, these calculations, the RWL, and the CLI are determined for you.

Script Narration for Lesson 2, Class 3, Screen 8

Because each single-task component lift in a multi-task job may place different stress on the body, each component lift must be analyzed separately. The multi-task calculator uses several intermediate values for each single-task lift. The first of these special calculations is the Frequency-Independent Recommended Weight Limit, or FIRWL. The automatic calculator allows you to develop FIRWL’s for the origin of each single-task lift and for the destination if significant control is involved.

Script Narration for Lesson 2, Class 3, Screen 9

First, compute the Frequency-Independent Recommended Weight Limit (FIRWL) for each task in the job. Next, the FIRWL for each task is multiplied by its appropriate frequency multiplier (FM) to obtain the Single-Task Recommended Weight Limit, or STRWL. The STRWL reflects the demands of each individual task, assuming it was the only task being preformed. Unlike the FIRWL, the STRWL includes the frequency for each single-task lift. Once the FIRWL is determined, the calculator will determine each STRWL. If significant control is required, data must be entered for both the origin and destination of each component single-task.

Script Narration for Lesson 2, Class 3, Screen 10

Once these data are entered, the calculator will also determine a Frequency-Independent Lifting Index, or FILI. The FILI for each task is calculated by dividing the maximum load weight (L) for that task by the respective FIRWL. The FILI reflects the stress on the body regardless of the frequency of the lifts. An FILI greater than 1 indicates which component lifts of the multi-task lifting job may need to be redesigned. Redesigning unsafe lifts will be discussed in Lesson 3.
Two load weights may need to be determined; the maximum load weight and the average load weight. The maximum load weight is the maximum weight lifted in the lifting job, and is used because the maximum load weight determines the maximum biomechanical loads (stress) imposed on the worker, regardless of the frequency of occurrence. The average load weight is also used because it represents the average demands (stress) on the worker distributed across all tasks, rather than demands dependent on a particular component task of the multi-task job. Both the maximum load weight and average load weight for each single-task component in a multi-task job must be entered into the automatic calculator. The calculator uses the average load weight to compute a Single-task Lifting Index, or STLI.

The calculator determines the STLI for each task by dividing the Single-task Recommended Weight Limit by the average load weight for each single-task component of the multi-task lifting job. The STLI can be used to identify individual tasks that place excessive physical demands on the worker. An STLI greater than 1 indicates the lift may need to be redesigned. However, even if all the STLI’s are less than or equal to 1.0, the CLI, which represents the combined demands of the lifts may still be significantly greater than 1.0.

Each subsequent task adds to the stress on the worker’s body. The Single-task Lifting Index measures the demands of each single-task component. Taking into account each STLI, the calculator computes the Composite Lifting Index (CLI) for the overall job. Remember, the CLI represents the combined physical demands (stress) of all the components of the multi-task job. The CLI is useful for determining if the overall job needs to be redesigned.

Multi-task lifting jobs are composed of multiple single-task components. Each single-task lifting component must be analyzed separately. Fortunately, the automatic calculator can compute all the values needed to assess multi-task lifts. Once all data are entered, the calculator will report the key measures for each single-task component. The calculator will rank these tasks in decreasing order of stress. Lifts posing the most stress should be addressed first. The calculator will permit on-screen adjustments to examine “what if” scenarios until a safe lift can be determined. Redesigning jobs will be discussed in the next lesson.

In this lesson we have defined multi-task jobs as composed of separate single-task lifts. We have discussed why multi-task jobs can place greater stress on the worker. We have discussed the calculations necessary to analyze multi-task lifting jobs. We have introduced you to the Composite Lifting Index and demonstrated how to input data for multi-task jobs into the calculator. In the next lesson, we will discuss how to use the Lifting Index and automatic calculator to redesign unsafe lifts.
LESSON 3, CLASS 1

Script Narration for Lesson 3, Class 1, Screen 1

The automatic calculator computes the Recommended Weight Limit, the Lifting Index for single-task lifts, and the Composite Lifting Index for multi-task lifts. These computations will help you to redesign unsafe lifts.

Script Narration for Lesson 3, Class 1, Screen 2

In this lesson you will learn how to input the required measurements for all seven variables necessary to determine the RWL and LI for single-task jobs, and RWL and CLI for multi-task jobs into their appropriate screens of the automatic calculator.

Script Narrative for Lesson 3, Class 1, Screen 3

You may download or print the single or multi-task job analysis worksheets by clicking the mode button located on the toolbar at the top of the calculator screen. Next, click on the respective task buttons for either single or multi-task and enter the required data as you measure each lifting task condition. Finally, select file and click on the save or print option to save or print the data currently displayed on the calculator screen. The worksheets can also be found in the Applications Manual for the Revised NIOSH Lifting Equation.

Script Narration for Lesson 3, Class 1, Screen 4

The calculator screens for single and multi-task lifts are different because multi-task lifts require more information.

Script Narration for Lesson 3, Class 1, Screen 5

The single-task screen will appear when you open the calculator. If you need to go to the multi-task screen, click "multi-task" under the "mode" option on the toolbar. We will discuss the single-task screen first.

Script Narration for Lesson 3, Class 1, Screen 6

Enter the appropriate information in the top section of the calculator screen. These fields are for your convenience and are not required for the calculator to compute the RWL and LI. You can enter a time and date by clicking on the respective time and date boxes and entering a time and date. You can automatically enter the current time and date by clicking on the current time and date box.

Script Narration for Lesson 3, Class 1, Screen 7

Next, select either metric or English measurements by going to the “settings” option on the toolbar.
Determine if the lift requires significant control. If the lift does not require significant control, enter the following data: the load weight; the horizontal location at the origin; the vertical location at the origin and destination; angle of asymmetry at the origin; frequency of lifting in lifts per minute; duration in hours, converted to one of three categories; coupling classification, converted to one of three categories; and select "no" for significant control.

Enter the data into the calculator. The RWL and LI should appear after you enter all the pertinent data. Remember all the required data fields must have an entry.

If you have entered all the data and the RWL or LI is zero, you may have exceeded the restrictions for a variable. If so, the label above the data entry box for that variable will appear red.

Check each red box for typographical errors. If the information is correct and a box remains red, make sure you have not exceeded the restriction parameters for the variable or variables in question. The restriction parameters for the variables are presented both in table format and in formulas in the Applications Manual for the Revised NIOSH Lifting Equation, included on this CD-ROM. To view the applications manual, select the class map screen, select PDF MANUAL, use the scroll function to get to the table of contents and to navigate to the desired pages.

The calculator allows you to investigate how each variable affects the RWL and LI for each single-task lift. If you know which variables can be altered to design a safer lift, enter the revised data. The RWL and LI calculations will update as each variable is changed.

Here are sample measurements for a single-task lift that does not require significant control. The weight to be lifted is 40 pounds. The vertical location of the hands is 15 inches at the origin and 36 inches at the destination. This converts to a VM of 0.888, and to a DM of 0.906. The horizontal location of the hands is 18 inches at the origin and 10 inches at the destination. This converts to a HM of 0.556. The asymmetric angle is 45 degrees at the origin and also 45 degrees at the destination of the lift. This converts to a AM of 0.856. The frequency rate is 0.2 lifts per minute and the lifting duration is less than 1 hour. This converts to a FM of 1.000. The coupling is classified as fair. This converts to a CM of 0.950. The RWL computes to 18.521 and the LI to 2.16. Remember rounding error does have an effect on the final LI results, but the LI for the above example should be between 2.1 and 2.2.
When these measurements are entered into the calculator, the LI = 2.16 (rounded to 2.2). This value is greater than 1, which indicates the lift may need to be redesigned, if possible.

Script Narration for Lesson 3, Class 1, Screen 15

Generally the multipliers with the lowest values indicate which variables may be altered first to reduce the LI. In the previous example the horizontal multiplier is the smallest multiplier at 0.56. This value can be increased by bringing the load closer to the worker.

Script Narration for Lesson 3, Class 1, Screen 16

In addition to bringing the load closer to the worker, we can further make this a safer lifting job by lowering the load weight, decreasing the angle of asymmetry, and raising the height at the origin to increase the VM. We may choose to redesign the lift by making adjustments in one or more of these lifting task conditions.

Script Narration for Lesson 3, Class 1, Screen 17

The lift in this example can be redesigned as follows:

- Bring the load closer to the worker. If the horizontal location is decreased to 10 inches, it increases the HM to 1.000.
- Reduce the angle of asymmetry to 30 degrees.
- Reduce the load weight to 30 pounds.

The combination of the above redesigns brings the LI down to 0.85 which indicates a safer lifting job.

Script Narration for Lesson 3, Class 1, Screen 18

If a single-task lift requires significant control, enter the measurements for the horizontal location at both the origin and at the destination of the lift. Enter the measurements for the angle of asymmetry at both the origin and at the destination of the lift. The calculator will determine the RWL and LI for both the origin and the destination. Compare the LI at the origin of the lift to the LI at the destination to determine which part of the lift is most stressful. Remember, the lower of the two RWL values (origin and destination) is used to assess the overall lift. After assessing the overall lift and if it is determined that the lift needs to be redesigned, the most stressful part of the lift should be redesigned first.
Attachment 3 - Subject Knowledge and Skills Evaluation

All the following questions comprise the final evaluation.

Final Evaluation Directions

1. You may not consult any external sources.

2. The exam contains 48 questions of equal weight.

3. You are permitted up to 1 hour to complete the evaluation, but you may leave sooner if you wish.

4. The evaluation period begins once you are told to start.

5. If you have any questions about these directions, ask the proctor before you begin the evaluation.

6. During the evaluation, the proctor will only take questions about the evaluation process and content questions are not permitted.

Good luck!
Subject Knowledge and Skills Evaluation

Question 1

To calculate a Recommended Weight Limit (RWL), the NIOSH Lifting Equation requires accurate measurement of seven variables. From the selection below, identify one of these variables.

a. duration of lifting
b. significant control
c. point of projection
d. health of lifter

Question 2

To calculate a Recommended Weight Limit (RWL), the NIOSH Lifting Equation requires accurate measurement of seven variables. From the selection below, identify one of these variables.

a. mid-knuckle point
b. horizontal location
c. asymmetry line
d. Lifting Index

Question 3

To calculate a Recommended Weight Limit (RWL), the NIOSH Lifting Equation requires accurate measurement of seven variables. From the selection below, identify one of these variables.

a. RWL
b. vertical location
c. mid-ankle point
d. room temperature

Question 4

To calculate a Recommended Weight Limit (RWL), the NIOSH Lifting Equation requires accurate measurement of seven variables. From the selection below, identify one of these variables.

a. sagittal line
b. mid-sagittal plane
c. angle of asymmetry
d. single-task lifts
**Question 5**

To calculate a Recommended Weight Limit (RWL), the NIOSH Lifting Equation requires accurate measurement of seven variables. From the selection below, identify one of these variables.

a. coupling classification  
b. lifting index  
c. multiplier  
d. high speed motion

**Question 6**

To calculate a Recommended Weight Limit (RWL), the NIOSH Lifting Equation requires accurate measurement of seven variables. From the selection below, identify one of these variables.

a. neutral body position  
b. frequency of lifts  
c. task analysis  
d. job redesign

**Question 7**

To calculate a Recommended Weight Limit (RWL), the NIOSH Lifting Equation requires accurate measurement of seven variables. From the selection below, identify one of these variables.

a. vertical travel distance  
b. multi-task lifts  
c. age of lifter  
d. load constant

**Question 8**

The NIOSH Lifting Equation is appropriate for estimating risk of low back injury in which of the following lifting situations?

I. Holding, carrying, and pushing objects  
II. Walking and climbing with objects and overhead lifting  
III. Lifting up to 10 hours  
IV. One-handed lifting  
V. Lifting with mechanical assistance
a. All
b. None
c. I and IV only
d. II and V only
e. I, II, IV, and V only

**Question 9**

When using the automatic calculator, the duration of continuous lifting can be short, moderate, or long. Select the correct time for a moderate duration.

a. 1-2 hours
b. 1-3 hours
c. 2-3 hours
d. 1-4 hours
e. 3-4 hours

**Question 10**

When using the automatic calculator, the duration of continuous lifting can be short, moderate, or long. Select the correct time for a long duration.

a. 3-4 hours
b. 4-6 hours
c. 2-8 hours
d. 5-8 hours
e. >8 hours

**Questions 11 and 12**

The Lifting Index (LI) is a numerical indicator of risk of injury. The LI is determined by dividing \(11\)__________________ by \(12\)__________________________.

11.
a. RWL
b. load constant
c. load weight
d. index constant

12.
a. RWL
b. load constant
c. load weight
d. index constant
Question 13

When calculating the RWL, determine if significant control is required ________________

a. at the start of the lift.  
   b. throughout the lift.  
   c. at the destination of the lift.

Question 14

_________________________ is the distance between the mid-ankle point and the point-of-projection along the surface of the floor. 

a. Vertical location  
   b. Horizontal location  
   c. Angle of asymmetry  
   d. Vertical travel distance

Question 15

______________________ is the distance between the mid-knuckle point and the spot on the floor directly below the mid-knuckle point. 

a. Vertical location  
   b. Horizontal location  
   c. Angle of asymmetry  
   d. Vertical travel distance

Question 16

The Revised NIOSH Lifting Equation uses which of the following variables to calculate a Recommended Weight Limit?

I. Horizontal location at the beginning of the lift and vertical location at the beginning of the lift.
II. Horizontal location at the destination of the lift and vertical location at the destination of the lift if significant control is required.
III. The angle asymmetry, frequency, duration, and the coupling classification at the beginning of the lift.
IV. The angle asymmetry, frequency, duration, and the coupling classification at the destination of the lift if significant control is required.

a. All of the answers are correct.  
   b. I and III only  
   c. II and IV only
d. None of the answers are correct.

**Question 17**

Which of the following statements are true?

I. A Lifting Index of 1 means the load weight equals the RWL.
II. The lower the Lifting Index value, the greater the risk of injury.
III. The greater the Lifting Index, the safer the lifting job.
IV. The lifting task with the lowest Lifting Index value is the safest.

a. I and IV only  
b. II and IV only  
c. III and IV only  
d. None of the answers are correct

**Question 18**

Identify whether the recovery time (RT) is adequate (a) or inadequate (b) for a worker doing continuous lifting (CL).

<table>
<thead>
<tr>
<th>Activity</th>
<th>CL</th>
<th>RT</th>
<th>CL</th>
<th>RT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minutes</td>
<td>90</td>
<td>10</td>
<td>20</td>
<td>90</td>
</tr>
</tbody>
</table>

a. adequate  
b. inadequate

**Question 19**

Identify whether the recovery time (RT) is adequate (a) or inadequate (b) for a worker doing continuous lifting (CL).

<table>
<thead>
<tr>
<th>Activity</th>
<th>CL</th>
<th>RT</th>
<th>CL</th>
<th>RT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minutes</td>
<td>30</td>
<td>10</td>
<td>45</td>
<td>10</td>
</tr>
</tbody>
</table>

a. adequate  
b. inadequate

**Question 20**

Adequate rest periods neutralize the stress on the body from lifting. For the work pattern below, identify (circle answer) the correct duration for the lifting job, taking into account periods of continuous lifting (CL) and recovery times (RT). All times are given in minutes.

<table>
<thead>
<tr>
<th>Work Pattern</th>
<th>CL</th>
<th>RT</th>
<th>CL</th>
<th>RT</th>
<th>CL</th>
<th>RT</th>
<th>CL</th>
<th>RT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60</td>
<td>10</td>
<td>60</td>
<td>40</td>
<td>60</td>
<td>10</td>
<td>60</td>
<td>40</td>
</tr>
</tbody>
</table>
a. = #1 hour
b. = 1-2 hours
c. = 2-8 hours
d. cannot tell from the above information

Question 21

Some jobs involve a series of different tasks. These jobs are called multi-task lifting jobs. Which of the following is not a multi-task job?

a. Lifting 35-pound rolls of paper from a cart and carefully positioning each roll in a box.
b. Unloading cartons from a pallet and stacking them vertically from the floor in five tiers.
c. Unloading cans of liquid from a cart and placing them on three shelves, and each shelf is a different vertical height.
d. Removing 5-pound rolls of paper from a moving conveyer, placing them in boxes and stacking the boxes on a work table.

Question 22

If a load is difficult to handle, the worker must reposition his hands during the lift to maintain control. This condition often occurs when the load is . . .

I. Oddly shaped.
II. Likely to shift during the lift.
III. Fragile.
IV. Unexpectedly light.

a. All the answers are correct
b. I, III, and IV only
c. II, III, and IV only
d. I, II, and III only

Question 23

Significant control is required when a worker must do which of the following?

I Re-grasp the object near the destination of the lift
II Reposition his hands to hold an object
III Carefully position the object near the destination of the lift
IV Lean forward at the start of the lift with the weight bearing only on one foot
V Momentarily hold the object near the destination of the lift

a. All
b. II, III, IV, and V only
c. I, II, III, and IV only
d. I, II, III, and V only

**Question 24**
An FILI less than 1 indicates which component lifts of the multi-task lifting job may need to be redesigned.

a. True  
b. False

**Question 25**
Which of the following are true?

I. If you change a variable value, the automatic calculator will automatically update the RWL.

II. The automatic calculator computes the Recommended Weight Limits and Lifting Indexes for both single and multi-task lifts.

III. The automatic calculator cannot be used for multi-task lifts requiring significant control.

IV. The automatic calculator can be used for multi-task lifting jobs consisting of up to 5 separate component single task lifts.

a. I and II only  
b. I, II, and III only  
c. I, II, and IV only  
d. All of the above are true

**Question 26**
The weight to be lifted (44 lbs) is greater than the RWL at both the start and the destination of the lift (16.3 lbs and 14.5 lbs, respectively).

Which places greater stress on the worker’s body?

a. lifting up the object  
b. setting down the object

**Question 27**
To find the frequency component, divide the total number of lifts during _____________ by 15.

a. a representative 15-minute segment of the lifting job  
b. the first 15-minute segment of the lifting job  
c. the last 15-minute segment of the lifting job  
d. the first and last 15-minute segments of the lifting job
Question 28

A punch press operator loads a heavy reel of supply stock from the floor onto the punch press table which is at waist height. Significant control of the load is required at the destination of the lift due to the design of the punch press. The multipliers and RWL’s for this lift are recorded on the job analysis worksheet below.

<table>
<thead>
<tr>
<th>Lift</th>
<th>LC (x)</th>
<th>HM (x)</th>
<th>VM (x)</th>
<th>DM (x)</th>
<th>AM (x)</th>
<th>FM (x)</th>
<th>CM (=)</th>
<th>RWL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start</td>
<td>51 lbs</td>
<td>.44</td>
<td>.89</td>
<td>.86</td>
<td>1.0</td>
<td>1.0</td>
<td>.95</td>
<td>16.3 lbs</td>
</tr>
<tr>
<td>End</td>
<td>51 lbs</td>
<td>.44</td>
<td>.75</td>
<td>.86</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>14.5 lbs</td>
</tr>
</tbody>
</table>

The weight to be lifted (44 lbs) is greater than the RWL at both the start and the destination of the lift (16.3 lbs and 14.5 lbs, respectively). Which of the following job modifications would reduce the risk of injury from this lift?

a. Move the punch press table further away from the worker at the destination so as to increase the HM.
b. Raise the destination of the lift so as to decrease the VM.
c. Modify the vertical travel distance between the start and the destination of the lift to decrease the DM.
d. Modify the job so that significant control at the destination is not required.
e. Both answers c. and d.

Question 29

In order to accomplish a lift, the worker may lean forward with the weight bearing on only one foot. The worker’s other foot may be raised or slightly touching the ground so as to act as a counter-balance. In either case the total weight of the lift is supported by only one foot. This will affect the measurement of the __________.

a. Vertical Location (V)
b. Vertical Travel Distance (D)
c. Horizontal Location (H)
d. All the above are correct

d. All the above are correct

Question 30

Consider the following work schedule:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous lifting</td>
<td>1 hour</td>
</tr>
<tr>
<td>Break</td>
<td>10 minutes</td>
</tr>
<tr>
<td>Continuous lifting</td>
<td>1 hour</td>
</tr>
<tr>
<td>Lunch</td>
<td>30 minutes</td>
</tr>
</tbody>
</table>
What is the appropriate lifting duration for this lifting job?

a. short
b. moderate
c. long

**Question 31**
In Multi-Task Lifting Jobs the characteristics of individual lifts within the same job are different. The individual lifts can be grouped into a small set of separate simple lifts that can be analyzed using a multi-task approach. Which of the following are multi-task lifting jobs?

I. Palletizing or depalletizing jobs in which the vertical height of a lift is determined by the vertical height of the row in the stack
II. Sequential jobs in which multiple objects of different weights are lifted in a predictable sequence
III. An assembly job in which two separate parts are lifted to a table, pieced together and then placed on a shelf
IV. Packing operations in which individual items are packed into a box before the box itself is lifted

a. All
b. I, III, and IV only
c. II, III, and IV only
d. I, II, and IV only

**Question 32**
Which of the following lifting condition is most likely to increases stress on the body?

I. The careful positioning of a roll of paper into a box at the destination of a lift
II. Guiding a box of supplies into place on a pallet
III. Placing a box of small engine parts on a conveyer belt
IV. Relocating and positioning paint cans from a table to an overhead shelf

a. All the above answers are correct
b. I, III, and IV only
c. II, III, and IV only
d. I, II, and IV only

*Questions 43–50 pertain to the single-task lift shown in the picture. Each picture will ask a*
question (located at the top of the picture). You should answer each question by clicking or marking (WITH AN X) the correct answers. The center of the X will be graded as the point chosen as your answer. If the question is a multiple choice, then circle the correct answer.

This is where I put the color slides used to test for the correct placement of the measurement points to correctly use the lifting equation.
Attachment 4 - Technology Attitudes Evaluation

Technology Attitudes Evaluation

1. I am comfortable writing using only a computer.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

2. I do poorly on exams when I take them using a computer.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

3. The world is a better place to live because of computers.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

4. I believe computer technology eliminates jobs.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

5. Computers and their related technologies are good for people.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

6. Computer technology will create employment opportunities for me.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

7. I distrust computers.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

8. Computer-based training is as effective or better than training that relies on text alone.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

9. The world is so complex that we will need computer technology to survive another 50 years.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree
10. The world was a much better place before computer technology existed.

a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree
Attachment 5 - Self-Perception of Learning Evaluation

(Note: “Self-directed” is referred to as “self study” in this report of the study findings.)

Self-Perception of Learning Evaluation

1. The training program that I just completed furnished me with the knowledge and skills required to master the lifting equation material.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

2. The training materials used in my training (CD-ROM or Text) were adequate for effective learning of the lifting equation material.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

3. The NIOSH training program that I just completed was one of my best learning experiences.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

4. The method of training delivery used in my training (CD-ROM or Text and instructor or self-directed) was the main reason for my excellent learning experience.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

5. I feel good about the over-all learning experience from my training program.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

6. The learning climate (classroom, projector or computer, etc…) used in my training program was effective in providing an atmosphere conducive to learning.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

7. The training program that I have just completed provided a sound, well designed coverage of the NIOSH lifting equation and its use.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

8. After completing the NIOSH lifting equation training program, I am confident I can use the NIOSH lifting equation to correctly evaluate the safety of a lifting task.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree
9. The instructional approach used in my training (with instructor or self-directed) was the main reason for my excellent learning experience.

   a. Strongly agree   b. Agree   c. Disagree   d. Strongly Disagree

10. The knowledge and skills gained as a result of this training program will stay with me for life.

   a. Strongly agree   b. Agree   c. Disagree   d. Strongly Disagree
Attachment 6 - Subject Satisfaction Evaluation

(Note: “Self-directed” is referred to as “self study” in this report of the study findings.)

Subject Satisfaction Evaluation

1. I found the training program that I have just completed to be deficient in one or more areas.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

2. I would like to take more training using the methods (CD-ROM or text and instructor or self-directed) used in my training.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

3. I found the content of the training material to be adequate.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

4. I found the explanations, descriptions and examples used in the training material to be well designed.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

5. If I were to teach this training program, I would use the same approach (CD-ROM or Text and instructor or self-directed) used in the training I have just completed.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

6. I wish I had not wasted my time taking this training.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

7. I was satisfied with the materials (CD-ROM or Text) used in my training.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

8. I was satisfied with the instructional approach (instructor or self-directed) used in my training.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

9. I enjoyed my training.
   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree
10. I found this NIOSH training program to be a **fresh** approach to a safety-related problem.

   a. Strongly agree  b. Agree  c. Disagree  d. Strongly Disagree

**Open-ended (short answer):**

1. Are there things that you **liked better** about the NIOSH training program as compared to other training programs in which you have participated?

2. Are there areas that you felt the NIOSH training program needed **improvement** when compared to other training programs in which you have participated?
### Classroom (site) Behavioral Observation Checklist

(Note: “Self-directed” is referred to as “self study” in this report of the study findings.)

| Instructor Name if applicable | ________________________________ |
| Date | _____________________ |
| Length of Observation Period (in minutes) | __________ |
| Circle type of media: | CD-ROM | Written Text |
| Circle type of Instructional Method: | Instructor | Self-directed |
| Site (room) # | |
| Computer Equipped | YES | NO |

**Scoring Criteria:**
- Record number of behaviors or problems related to training dimensions or conditions.
- Record number of subjects affected by behaviors or problems.
- Record effects, if behavior affects or was affected by instructional method.
- If possible state problem and how it affected conditions. List again how many subject where affected and if (in your opinion) this negatively affects so as to confound training session. An example would be a power failure or system crash during a CD-ROM training session. An example of a situational problem would be seating closely so subjects assisted each other or environmental conditions being non-conducive to effective learning.
- Observations should be made as to steps to correct problem and was the problem effectively corrected (write yes or no).

<table>
<thead>
<tr>
<th>Training Dimension</th>
<th>Training Problems</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware (computers)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Software (CD-ROM)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subjects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instructional Method</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classroom (training site) situational</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Attachment 8 - Instructor Feedback Cards

Instructor Feedback Cards
National Institute for Occupational Safety and Health
NIOSH Lifting Equation Training

In order to improve the quality of the NIOSH lifting equation training materials, we would greatly appreciate your feedback regarding the materials we have provided. After completing each training session, we are asking that you please address the following questions. Business reply postage is provided for your convenience, or you may drop feedback cards in Dr. R. Houston’s mailbox. You are asked to please be prompt (same day if possible) about returning cards, as instructor comment reviews will be an on-going process. Should you have any questions, please contact: William Bowles Jr., Research Fellow (513)533-8368, or evening call (513) 553-4717.

Instructor Name_____________________________________________
Classroom Name or Number __________________ Date Used ___________________________
Starting time _____                                          Conditions of training site (Check all that apply)
Stopping time _____
Number of students in class _____

1. In your opinion, was the topic selected for today appropriate?
   Yes              No

2. Was the content of this session’s topic thorough and appropriate?
   Yes                 No

3. What was the response of the students to the materials?
   Very Interested        Somewhat Interested    Not Interested

4. Were the materials effective in conveying the lifting equation information to the subjects?
   Very Effective         Somewhat Effective     Not Effective

5. Did the subjects make any comments about the material or delivery method during the training session?
   Yes              No

6. What suggestions do you have for improvements to the materials that you presented this week?

7. (For CD-ROM method instructors only) Did any of the subjects have difficulty or express comments about the CD-ROM training program during the training session?
   Yes              No
8. If the answer to the above was yes, explain if possible

9. Do you have any other comments you’d like to share? (use the back of this page if you need more room). Please give us contact information if you would like us to call you to gather more in-depth opinions about this lesson.
## Attachment 9 - Sample Size Calculations

### Factorial Multivariate Analysis of Covariance (MANCOVA)

<table>
<thead>
<tr>
<th>Treatment Conditions</th>
<th>Covariates (3):</th>
<th>Unit of Analysis</th>
<th>Dependent Variables (3):</th>
</tr>
</thead>
<tbody>
<tr>
<td>(inter-combinations produce 4 treatment groups):</td>
<td>Knowledge evaluation pretest</td>
<td>Individual subject</td>
<td>Knowledge evaluation posttest</td>
</tr>
<tr>
<td>Instructor type (with or without instructor)</td>
<td>Attitude evaluation pretest</td>
<td></td>
<td>Attitude evaluation posttest</td>
</tr>
<tr>
<td>Learning medium (Text or cd-rom)</td>
<td>Self-perception pretest</td>
<td></td>
<td>Self-perception posttest</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Effect Size ($f^2$)</th>
<th>Total Sample Size</th>
<th>Total Number of Classrooms (10 subjects per class)</th>
<th>Number of Subjects per 4 Treatment Conditions</th>
<th>Number of Classrooms Per Each of 4 Treatment Conditions (10 subjects per class)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.02</td>
<td>715</td>
<td>71.5</td>
<td>179</td>
<td>18</td>
</tr>
<tr>
<td>.04</td>
<td>361</td>
<td>36</td>
<td>90</td>
<td>9</td>
</tr>
<tr>
<td>.06</td>
<td>243</td>
<td>24</td>
<td>61</td>
<td>6</td>
</tr>
<tr>
<td>.08</td>
<td>183</td>
<td>18</td>
<td>46</td>
<td>4.6</td>
</tr>
<tr>
<td>.10</td>
<td>148</td>
<td>15</td>
<td>37</td>
<td>3.7</td>
</tr>
<tr>
<td>.12</td>
<td>124</td>
<td>12</td>
<td>31</td>
<td>3</td>
</tr>
<tr>
<td>Medium</td>
<td>100</td>
<td>10</td>
<td>25</td>
<td>2.5</td>
</tr>
</tbody>
</table>

### Sequence of Calculations

\[
\begin{align*}
\alpha &= .05 \quad (95\% \text{ level of confidence}) \\
\lambda &= \text{noncentrality parameter} \\
K_t &= \text{number of treatment conditions} \quad K_h = \text{number of training groups} \\
K_x &= (K_t)(K_h) = \text{number of independent variables} \quad K_y = \text{number of dependent variables} \\
u &= (K_x)(K_y) = (\text{Degrees of freedom of the numerator of F ratio}) \quad K_A = \text{number of covariates} \\
v &= (\text{Degrees of freedom of the denominator of the F ratio - Table 9.3.2 Cohen})
\end{align*}
\]
\[ s = \sqrt{\frac{K_x^2 K_y^2 - 4}{K_x^2 + K_y^2 - 5}} \]

\[ \lambda_U = \text{Upper limit from Table 9.4.2 (Cohen, 1998, p. 452-455)} \]

\[ \lambda_L = \text{Lower limit from Table 9.4.2 (Cohen, 1998, p. 452-455)} \]

**Step 1.**

\[ V_L = \frac{\lambda_U}{f^2} - u - 1 \]

(Cohen, 1988, section 10.4, p. 514-530, erratum in formula 10.4.1 noted)

**Step 2.**

\[ \lambda_u = \lambda_L - \frac{1}{V_L} - \frac{1}{V_U} (\lambda_u - \lambda_L) \]

**Step 3.**

\[ V' = \frac{\lambda_L}{f^2} - u - 1 \]

**Step 4.**

\[ N = \frac{1}{s} \left( V' + \frac{u}{2} - 1 \right) + \left( \frac{K_y + K_x + 3}{2} \right) + \max(K_C, K_A + K_G) \]

(Total sample size)
You have been asked to participate in a NIOSH research study. This fact sheet provides information regarding the purposes of the study and what your participation would include.

**Purpose**
This study is being conducted in order to evaluate the effectiveness of NIOSH lifting equation CD-ROM training program. We want to know if the multimedia CD-ROM-based training is as, or more effective than traditional written text training material.

**Your Participation**
As a participant in this study you will attend training program that has been developed to evaluate the effectiveness of the NIOSH CD-ROM training. The training will be provided within the timeline of one academic quarter, and will be coordinated through your departmental instructors. The training sessions will be conducted during class-time and there-fore will last no longer than your regular class. The number of training session will vary as a result of differences in class length, but should approximate four sessions (total). Information regarding the effectiveness of the training will be collected through written evaluations and classroom (site) observations.

You will be asked to fill out an extensive written evaluation (Subject knowledge and skills evaluation) after the last class. You will also be asked to fill out several brief evaluations concerning you feelings about the training program you have just completed, and what you thought of the training overall. The brief evaluations should only take ten to fifteen minutes to complete.

**You’re Rights**
Your participation in this study is voluntary; you may withdraw your consent, refuse to participate, or end your participation in this study at any time without penalty or loss of course credits and grades to which you are otherwise entitled. If you have questions about this research or your rights as a member of this study, contact William Bowles or Terri Heidotting at the addresses and phone numbers listed below.

**Protecting Identity**
Your name will be recorded on the evaluations. When your responses are entered into our database, your name will be removed. Your name will not be used when reporting the findings of this study.

**Who to Contact**
If you have any questions regarding any aspect of this study, please contact one of the following. A toll-free number is also provided for your convenience, please call 1-800-35-NIOSH (1-800-356-4674) and representatives can transfer your call to the individual listed below.

<table>
<thead>
<tr>
<th>William Bowles Jr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Fellow</td>
</tr>
<tr>
<td>NIOSH</td>
</tr>
<tr>
<td>Division of Education and Information</td>
</tr>
<tr>
<td>4676 Columbia Parkway</td>
</tr>
<tr>
<td>Cincinnati, OH. 45226</td>
</tr>
<tr>
<td>(513) 533-8368</td>
</tr>
</tbody>
</table>
EVALUATING A NIOSH CD-ROM TRAINING PROGRAM FOR THE NIOSH LIFTING EQUATION

Introduction:
Before agreeing to participate in this study, it is important that the following explanation of the proposed procedures be read and understood. It describes the purpose, procedures, risks, and benefits of the study. It also describes the right to withdraw from the study at any time. It is important to understand that no guarantee or assurance can be made as to the results of the study.

Purpose of the Study:
The primary purpose of the study is to compare the effectiveness of two training mediums (computer-presented CD-ROM and textbook-presented written text) and of two instructor learning conditions (instructor and no-instructor).
This study will evaluate the effectiveness of a NIOSH CD-ROM training program for manual lifting tasks with respect to enhancing knowledge, skills, attitudes, and behaviors regarding safe work practices. By comparing traditional text and instructor-led training with multimedia methodologies, this study will determine whether the use of multimedia technologies in training enhances learning and performance. This study will provide a self-directed multimedia CD-ROM administrated training program using the Revised NIOSH Lifting Equation training CD-ROM.

Number of Participants:
You will be one of approximately 600 participants taking part in this study.

Duration:
Your participation in this study will last for approximately 60-150 minutes each week for approximately 1-3 weeks.

Procedures:
During the course of this study, the following will occur:
A. You will be asked to complete a short (5 minute) pre-training background experience survey addressing prior exposure to computers, CD-ROM-based software, or lifting equations.

B. You will then receive 60-150 minutes of training a week for 1-3 weeks in one of four instructional conditions. One instructional intervention will consist of multimedia training that uses the NIOSH lifting equation CD-ROM as an instructional medium.

Subjects in the CD-ROM learning condition will use the NIOSH lifting equation CD-ROM as an instructional medium. This condition will be self-directed (non-instructor led).
Another condition is a non-CD-ROM learning condition. In this condition subjects will have a written lifting equation text as their instructional medium, and this too will be self-directed. There will also be one group in both the CD-ROM and written text learning conditions that will be instructor led. For the instructor-led learning conditions, training will be administered by University of Cincinnati instructors. For the non-instructor-led (self-directed) learning conditions, observers will be either instructors or study researchers.

C. Once you have completed your training program, you will be asked to complete several post-training surveys and a final quiz. The surveys and quiz should take less than 90 minutes to complete, although you will be allocated 150 minutes as a maximum time limit. The primary investigator (William Bowles) will administer all pre-training and post-training surveys and quizzes, and will collect the surveys and quizzes upon their completion. You will be asked to record your name on the surveys and quiz. Because this training is conducted within a university course, which requires registration by students, your attendance will be monitored as this is a requirement of the course. The instructors will provide the primary investigator with copies of the attendance lists. For purposes of data organization your name will be assigned a code. Attendance, survey and quiz data will then be code-matched, with no personal identifying characteristics or names used. No form of tracking using personal identifying information will be attempted by the researchers, although as previously stated this study is conducted as part of a university course and the instructor will take attendance, as required by the college. Information obtained during the study will be confidential and only be used by the primary investigator in this study.

D. If you choose to withdraw from the study, any data from your participation will be excluded from the study and will be excluded from the final data analyses. Following your participation in this study, you will have the opportunity to provide feedback to the primary investigator, or the instructor if you choose, as to your satisfaction with the study.

**Risks and Discomforts:**

There are no presumed risks associated with this study. This study does not present greater than a minimal risk of harm to the participants. While the university requires your attendance at your class sessions, your participation in filling out the pre-training and post-training evaluations is entirely voluntary and you may withdraw from participation at any time without penalty or prejudice. These informed consent parameters are being described orally and in this document at the beginning of this study. This study is research related and the training administered and data obtained will be used for research purposes only.

**Benefits from Study:**

Possible benefits that you may receive from your participation in this study is an increased awareness of current and future training technologies and a heightened awareness of safer lifting practices. You will also be able to keep part of the training program materials used in the NIOSH lifting equation training programs, although these will be distributed after the completion of the study.
Alternatives:
If you choose not to participate in this study, you may still take this class. You will still have access to available study materials, and receive study related training, but no attempt will be made by the study researchers to collect any type of study or non-study related information.

New Findings:
You will be told if there is any new information that becomes available during the course of the study that may affect your willingness to continue participation in the study.

Right to refuse or withdraw:
Your participation is voluntary and you may refuse to participate, or may discontinue participation AT ANY TIME, without penalty or loss of benefits to which you are otherwise entitled. The investigator has the right to withdraw you from the study AT ANY TIME. Your withdrawal from the study may be for reasons related solely to you (for example, not following study-related directions from the investigator, etc.) or because the entire study has been terminated.

Offer to answer questions:
If you have any other questions about this study, you may call William Bowles at 513-553-8368 or Dr. Ken Martin at 513-556-3582. If you have any questions about your rights as a research participant, you may call Dr. Margaret Miller, Chair of the Institutional Review Board – Social and Behavioral Sciences, at 513-558-5784.

LEGAL RIGHTS:
Nothing in this consent form waives any legal right you may have nor does it release the investigator, the sponsor, the institution, or its agents from liability for negligence.

I HAVE READ THE INFORMATION PROVIDED ABOVE. I VOLUNTARILY AGREE TO PARTICIPATE IN THIS STUDY. I WILL RECEIVE A COPY OF THIS CONSENT FORM FOR MY INFORMATION.

Participant Signature                  Date

Legal Representative/Parent Signature                  Date

If verbal assent/consent was obtained, check this box and have a witness sign and date below.

Witness Signature (required only for verbal assent)                  Date

Signature and Title of Person Obtaining Consent                  Date

Identification of Role in the Study
Attachment 11 - Study Guide

Guide for my in-class presentation:

Study Guide:
1. The primary product of the Lifting equation is the recommended weight limit (RWL) which reduces the maximum allowable weight (LOAD CONSTANT, LC=51Lbs.) to a value reflecting the conditions of the lift.

To calculate a Recommended Weight Limit (RWL), the NIOSH Lifting Equation requires accurate measurement of seven variables. They are:
   a. duration of lifting
   b. horizontal location
   c. vertical location
   d. angle of asymmetry
   e. coupling classification
   f. frequency of lifts.
   g. vertical travel distance

The Revised NIOSH Lifting Equation uses all of the following variables to calculate a Recommended Weight Limit:
   a. Horizontal location at the beginning of the lift and vertical location at the beginning of the lift.
   b. Horizontal location at the destination of the lift and vertical location at the destination of the lift if significant control is required
   c. The angle asymmetry, frequency, duration, and the coupling classification at the beginning of the lift.
   d. The angle asymmetry, frequency, duration, and the coupling classification at the destination of the lift if significant control is required.

2. The NIOSH Lifting Equation is NOT appropriate for estimating risk of low back injury when:
   a. Holding, carrying, and pushing objects
   b. Walking and climbing with objects and overhead lifting
   c. Lifting over 8 hours
   d. Lifting with one hand
   e. Lifting with mechanical assistance

3. When calculating duration of lifting or using the automatic calculator, the duration of continuous lifting can only be classified as one of three durations: short (less than or equal to 1 hour), moderate (1 to 2 hours), or long (2 to 8 hours).

4. The Lifting Index (LI) is a numerical indicator of risk of injury. The LI is determined by dividing actual weight being lifted (LOAD WEIGHT) by the RWL.

5. When calculating the RWL, determine if significant control is required by examining the destination of the lift.
6. The Horizontal Location is the distance between the mid-ankle point and the point-of-projection along the surface of the floor.

7. The Vertical Location is the distance between the mid-knuckle point and the spot on the floor directly below the mid-knuckle point.

8. The Vertical Travel Distance is the absolute value of the difference between the vertical heights at the origin and destination of the lift.

9. The Angle of Asymmetry is how far to the side the object is displaced at the origin or destination of the lift.

10. The Lifting Frequency is the average number of lifts in a representative 15 minutes.

11. As stated before, the Duration of Lifting is Short, Moderate, or Long.

12. The Coupling Classification can only be one of three values: Good, Fair, or Poor.

13. A Lifting Index of 1 means the load weight equals the RWL.

14. The lifting task with the lowest Lifting Index value is the safest.

15. Adequate rest periods neutralize the stress on the body from lifting.

Given the continuous lifting (CL) and recovery time (RT) of:

<table>
<thead>
<tr>
<th>Minutes</th>
<th>CL</th>
<th>RT</th>
<th>CL</th>
<th>RT</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>10</td>
<td>20</td>
<td>90</td>
<td></td>
</tr>
</tbody>
</table>

This would be adequate because there is enough rest for the two hour duration.

16. Given the continuous lifting (CL) and recovery time (RT) of:

<table>
<thead>
<tr>
<th>Minutes</th>
<th>CL</th>
<th>RT</th>
<th>CL</th>
<th>RT</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>10</td>
<td>45</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

This is inadequate as there is not enough rest for either the one or two hour durations.

17. The work pattern below presents a lifting job of the moderate duration 1-2 hours; taking into account periods of continuous lifting (CL) and recovery times (RT) in minutes.

Work Pattern

<table>
<thead>
<tr>
<th>CL</th>
<th>RT</th>
<th>CL</th>
<th>RT</th>
<th>CL</th>
<th>RT</th>
<th>CL</th>
<th>RT</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>10</td>
<td>60</td>
<td>40</td>
<td>60</td>
<td>10</td>
<td>60</td>
<td>40</td>
</tr>
</tbody>
</table>

Note: There is not enough rest for the 1 hour duration, but there is enough resting time for the 1-2 hours duration.
18. Some jobs involve a series of different tasks. These jobs are called multi-task lifting jobs. Examples of multi-task lifting jobs are:

a. Unloading cartons from a pallet and stacking them vertically from the floor in five tiers.
b. Unloading cans of liquid from a cart and placing them on three shelves, and each shelf is at a different vertical height.
c. Removing 5-pound rolls of paper from a moving conveyor, placing them in boxes and stacking the boxes on a work table.

An example of a job which is NOT a multi-task job is lifting 35-pound rolls of paper from a cart and carefully positioning each roll in a box. This is a single-task lift but would require significant control.

19. If a load is difficult to handle because it is oddly shaped, likely to shift during the lift or fragile, the worker must reposition his hands during the lift to maintain control. This condition would require significant control. Significant control is also required when a worker must: Re-grasp the object near the destination of the lift; reposition his hands to hold an object, carefully position the object near the destination of the lift, or momentarily hold the object near the destination of the lift.

20. Significant control is not required because a load is unexpectedly light. Significant control is likewise not required if the worker has to lean forward with the weight bearing on only one foot.

21. The automatic calculator will automatically update the RWL when changes in variable values are made. The automatic calculator computes the Recommended Weight Limits and Lifting Indexes for both single and multi-task lifts. The automatic calculator can be used for multi-task lifting jobs consisting of up to 5 separate component single task lifts. The automatic calculator can be used for single and multi-task lifts requiring significant control.

22. In some cases the significant control required at the destination of the lift can impose greater stress on the body than the origin of the lift. Given a job with the weight to be lifted of 44 lbs and is greater than the RWL at both the start and the destination of the lift (16.3 lbs and 14.5 lbs, respectively). Does lifting up the object (origin) or setting down the object (destination) place greater stress on the worker’s body? At the origin the LI is $44/16.3=2.7$ and destination of $44/14.5=3.0$ indicates that setting down the object at the destination is more stressful.

23. Remember when calculating the frequency component, you must divide the total number of lifts during a representative 15-minute segment of the lifting job by 15. You must do this as the calculator will not do it for you.

24. A punch press operator loads a heavy reel of supply stock from the floor onto the punch press table which is at waist height. Significant control of the load is required at the destination of the lift due to the design of the punch press. The multipliers and RWL’s for this lift are recorded on the job analysis worksheet below.
The weight to be lifted (44 lbs) is greater than the RWL at both the start and the destination of the lift (16.3 lbs and 14.5 lbs, respectively). Which of the following job modifications would reduce the risk of injury from this lift?

- a. Move the punch press table further away from the worker at the destination so as to increase the HM. **NO**, This would the HM worst as the worker would have to reach farther (more stress).

- b. Raise the destination of the lift so as to decrease the VM. **NO**, raising the destination lowers the multiplier and produces more stress.

- c. Modify the vertical travel distance between the start and the destination of the lift to decrease the DM. **NO**, the DM’s are the same and the multipliers are fairly large, so there is probably little improvement to be had here.

- d. Modify the job so that significant control at the destination is not required. **YES, the LI at the destination is high. This is the modification that should be addressed.**

- e. Both answers c. and d. **NO**, as we have already ruled out c.

25. In order to accomplish a lift, the worker may lean forward with the weight bearing on only one foot. The worker’s other foot may be raised or slightly touching the ground so as to act as a counter-balance. In either case the total weight of the lift is supported by only one foot. This will affect the measurement of the Horizontal Location by changing the total moment measurement for the lift.

26. Consider the following work schedule:

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<tbody>
<tr>
<td></td>
<td>Continuous</td>
<td>1 hour</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Break</td>
<td>10 minutes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous</td>
<td></td>
<td></td>
<td>1 hour</td>
<td></td>
</tr>
<tr>
<td>Lunch</td>
<td></td>
<td></td>
<td>30 minutes</td>
<td></td>
</tr>
<tr>
<td>Continuous</td>
<td></td>
<td></td>
<td></td>
<td>1 hour</td>
</tr>
<tr>
<td>Break</td>
<td></td>
<td></td>
<td></td>
<td>15 minutes</td>
</tr>
<tr>
<td>Continuous</td>
<td></td>
<td></td>
<td></td>
<td>1 hour</td>
</tr>
</tbody>
</table>

*What is the appropriate lifting duration for this lifting job?*
First, construct a CL/RT diagram for the lifting job as follows:

<table>
<thead>
<tr>
<th>CL</th>
<th>RT</th>
<th>CL</th>
<th>RT</th>
<th>CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>10</td>
<td>60</td>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>15</td>
<td>60</td>
<td></td>
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</tbody>
</table>

We can see that for the 1 hour (SHORT) duration that the rest time of 10 minutes is too small. We add the next CL time to the first and the rest time of 30 minutes is still too small for a 1-2 hour (MODERATE) duration, so this would be a **LONG** duration lifting job.

27. In Multi-Task Lifting Jobs the characteristics of individual lifts within the same job are different. The individual lifts can be grouped into a small set of separate simple lifts that can be analyzed using a multi-task approach. Which of the following are multi-task lifting jobs?

I. Palletizing or depalletizing jobs in which the vertical height of a lift is determined by the vertical height of the row in the stack
II. Sequential jobs in which multiple objects of different weights are lifted in a predictable sequence
III. An assembly job in which two separate parts are lifted to a table, pieced together and then placed on a shelf
IV. Packing operations in which individual items are packed into a box before the box itself is lifted

**These are all multi-tasking lifting jobs as they all fit the characteristics defined above.**

28. Which of the following lifting condition is most likely to increases stress on the body?

I. The careful positioning of a roll of paper into a box at the destination of a lift
II. Guiding a box of supplies into place on a pallet
III. Placing a box of small engine parts on a conveyer belt
IV. Relocating and positioning paint cans from a table to an overhead shelf

**Given the limited information, the correct answer is because Numbers I, II, and IV all involve the use of significant control, they will apply more stress.**
Instructions to Install the NIOSH Lifting Equation Tutorial:

Although you can install the LE CD on your hard drive, it works much easier off the CD disc in the CD drive. Insert the LE CD in the CD drive and it should auto install, but if it doesn't:
1. Click on Start (lower left of screen)
2. Click on RUN
3. Click on Browse
4. Click on Autorun.exe
5. Click on OPEN
6. Click on OK
7. You should get the Lifting Equation main screen
8. Click on Start

INSTRUCTIONS

Before beginning the training program you may want to view an explanation of the functions of the various screen navigation buttons. To return to the navigation screen, click on the “Back” button at the bottom of this screen. This will return you to the introductory (boot-up) screen. Click on the navigation button at the top right corner for a tutorial of the various button functions. After clicking into the navigation screen, you will be presented with a NIOSH Lifting Equation interface screen. The buttons presented on the left and right sides of this screen are found on each lesson screen. When in the training program, clicking on each button will link you to information related to the training program or the current topic. Clicking the “Play” button at the left lower corner of the navigation screen will display a list of the buttons (icons) that are used in this training program. By clicking the NEXT button at the lower right corner of the navigation page you will be given an explanation of the information provided by each button and its function related to the training program. Also, the host web browser functions, such as Back and Forward will continue to function when in the training program. Click on the “Return to Class” button below to return to the previous screen. From there you can click on the “Class Map” navigation button to begin the training program. Clicking on “Class Map” will present a screen with links to every screen in the training program. This will enable quick navigation to a previous stopping point, or to any screen in the training program.

To start the training program click on the class map button and select lesson 1. You will be presented with a screen consisting of two classes, each consisting of a list of topic screens. Select class 1, screen 1 to begin the Revised NIOSH Lifting Equation training program. Each screen (topic) should be viewed using the following steps:

- Select screen and listen to the narration and view the animation
- Select script button and read the script
When navigating through the program always use the displayed screen’s “BACK” or “RESTART” buttons as a first choice. You can also use the internet browser “BACK” button to return to a previous screen if the program fails to advance to a selected screen or correctly respond to a selected function.

**BACK**

Congratulations! You are about to embark on an exciting multimedia learning experience. To ensure a smooth trip, please review the following technical notes before you begin. This training program runs on your Web browser, eliminating the need for formal installation and setup. All files reside on the CD and do not need to be copied to your computer. Therefore, most users can begin using the program immediately.

**System requirements for running this program are listed below:**

- 400 MHz cpu (faster is better)
- 128 Mb RAM (more is better)
- Display set to 32 bit, millions of colors

**Software requirements:**

- Flash 6, or later player (download free at www.macromedia.com)
- QuickTime 5, or later player (download free at www.apple.com)
- Internet Explorer 6, or later.

**Troubleshooting:**

When playing video files, computers with slower processors (less than 533 MHz) or CD-ROM players (less than 30X) may exhibit some jerkiness. In most cases, this problem can be corrected by copying the entire program to your local hard drive, usually referred to as the "C:" drive. Select and copy the main folder "LE" and paste it in the new location, typically the C drive. All subfolders will follow the main folder to the new location and the original file structure will be retained. Copying files individually is not necessary nor is it recommended. If the file structure is disrupted, the program may not function properly. For ease of access, you may wish to create a shortcut to the program on your desktop.

**Program Components and Functions:**

If you are new to the Revised NIOSH Lifting Equation training program, click the instructions button for detailed instructions on the use of this training program. The Class Map will present a screen with links to every screen in the training program, to enable quick navigation to a previous stopping point. Click the class map button and select Lesson 1. You will be presented with a
screen consisting of two classes, each consisting of a list of topic screens. Select class 1, screen 1 to begin the Revised NIOSH Lifting Equation training program.

Before beginning the training program you may want to view an explanation of the functions of the various screen navigation buttons. Click on the navigation button above for a tutorial of the various button functions. After clicking into the navigation screen, you will be presented with a NIOSH Lifting Equation interface screen. The buttons presented on the left and right sides of this screen are found on each lesson screen. When in the training program, clicking on each button will link you to information related to the training program or the current topic.

Clicking the “Play” button at the left lower corner of the navigation screen will display a list of the buttons (icons) that are used in this training program. By clicking the NEXT button at the lower right corner of the navigation page you will be given an explanation of the information provided by each button and its function related to the training program. Also, the host web browser functions, such as Back and Forward will continue to function when in the training program.

Program Operating and Viewing Procedures:

Click on the “Return to Class” button below to return to the previous screen. From there you can click on the “Class Map” navigation button to begin the training program. Each screen (topic) should be viewed using the following steps:

• Select screen and listen to the narration and view the animation
• Select script button and read the script
• Clicking on the back button returns to the animation and narration
• Select quiz and complete the quiz
• The “Next” button goes to next screen, OR
• The “Back” button reviews the current screen
• From the animation screen click “next” to view the next screen, OR
• From the animation screen click “back” to view the previous screen

When navigating through the program always use the displayed screen’s “BACK” or “RESTART” buttons as a first choice. You can also use the internet browser “BACK” button to return to a previous screen if the program fails to advance to a selected screen or correctly respond to a selected function.
Addendums Provided to Study Subjects

Addendum 1: Weight on One Foot and Lift-Off Point

When measuring the lifting variables (H, V, A, etc.), it is important to identify the actual “lift-off” point for the lift. The lift-off point is defined as the point where the object first begins to move vertically or the weight of the object is supported by the worker. This should not be confused with the point where it first begins to move laterally. For example, when a worker lifts an object from a counter, he or she may slide or pull the object laterally toward his or her body before actually beginning to lift or lower the object vertically. In this case, the variables are measured at the point where the object (load) begins to move vertically rather than the point where the object began to move laterally.

Another example would be a lift in which the worker slides, pushes or pulls an object laterally off a counter and as the object completely clears the counter the weight of the object is supported by the worker.

When either of these conditions occurs, the horizontal location (H) and the angle of asymmetry (A) measurements may both be different than if the measurements were made when the object began to move laterally. In either case, the point where the weight of the object is supported by the worker is the lift-off point and is the starting point of the lift.

The horizontal Location (H) is the distance the worker’s hands extend out from the body. The farther the worker’s arms extend, the greater the stress on the body. When calculating horizontal location (H), the distance will be different if both feet are not planted on the ground. The worker may lean forward with the weight bearing on only one foot. The worker’s other foot may be raised or slightly touching the ground so as to act as a counter-balance. In either case, the total weight of the lift is supported by only the one foot. The horizontal component (H) is measured from directly below the weight bearing foot. This will result in a different horizontal location (H) than if the worker has both feet firmly planted on the ground.

In summary, two points are needed to measure horizontal location (H): 1) the point projected on the floor directly below the midpoint of the hand grasps (load center), and 2) the point measured from directly below the weight bearing foot if leaning forward on one foot, or from the midpoint of the line joining the inner ankle bones (MAP) if both feet are weight bearing. It is important to accurately assess whether the weight of the object being lifted is supported with one or both feet. Whether or not the worker is supporting the weight with one or both feet may make a difference in horizontal location (distance) and consequently a difference in the horizontal multiplier coefficient used in the lifting equation.

Addendum 2: The Automatic Calculator

NIOSH has created an automatic calculator that is capable of performing all the calculations required to compute the multipliers used in the Revised NIOSH Lifting
Equation. The measurements of each variable are entered into the appropriate areas of the automatic calculator and the variable multipliers, RWL, and LI are calculated and displayed. The automatic calculator can accept measurements in pounds and inches (English) or kilograms and centimeters (Metric). The automatic calculator also performs computations for lifts requiring significant control, but you must remember to click on the significant control box. Data for all the variables required by the Revised NIOSH Lifting Equation must be correctly measured and entered into the appropriate areas of the automatic calculator before a final RWL and LI will be displayed.

Care must be taken when entering a frequency number into the automatic calculator. Place your frequency result in the data entry box for variable F. The automatic calculator does not automatically divide the total number of lifts measured over a representative 15 minute time period by 15 when the total is entered into the data box for variable F. You must do this calculation, and then enter the results into the data box for variable F.

When using the calculator, enter the measurements for each variable at the beginning of the lift in the designated spaces. For lifts requiring significant control, measurements at the destination of the lift will also be required. When the box for significant control is clicked, boxes will appear for the destination measurements. Once all the measurements are entered, the Recommended Weight Limit is calculated automatically. The automatic calculator can also be used for multi-task lifting jobs.

Multi-task jobs are more difficult to evaluate because they involve more data. Using the Automatic Calculator, the multi-task approach is appropriate for multi-task lifting jobs consisting of up to 5 separate component single-task lifts. If the multi-task lifting job consists of more than 5 component lifts, the variability is too great to use the automatic calculator. (However, the Revised NIOSH Lifting Equation itself can accommodate a multi-task job with up to 10 separate component single-task lifts.

You may download or print the single or multi-task job analysis worksheets by clicking the mode button located on the toolbar at the top of the automatic calculator display. Next, click on the respective task buttons for either single or multi-task and enter the required data as you measure each lifting task condition. Finally, you can select file and click on the save or print option to save or print the data currently displayed on the calculator. The automatic calculator interface and display is similar to the worksheets used in the Applications Manual for the Revised NIOSH Lifting Equation. Remember, the calculator displays for single and multi-task lifts are different because multi-task lifts require more information.

The single-task display will automatically appear when you open the calculator. If you need to go to the multi-task screen, click "multi-task" under the "mode" option on the toolbar. We will discuss the single-task functions first.

Enter the appropriate information in the top section of the calculator display. These fields are for your convenience and are not required for the calculator to compute the RWL and LI. You can enter a time and date by clicking on the respective time and date boxes and entering a time and date. You can automatically enter the current time and date by clicking on the current time and date box.
Next, select either metric or English measurements by going to the “settings” option on the toolbar.

Remember if the lift requires significant control, you must click YES on the significant control box.

Next, enter the data into the calculator. The RWL and LI should appear after you enter all the pertinent data. Remember all the required data fields must have an entry.

If you have entered all the required data and the RWL or LI is zero, you may have exceeded the restrictions for a variable. If so, the label above the data entry box for that variable will be red. Check each red box for typographical errors. If the information is correct and a box remains red, make sure you have not exceeded the restriction parameters for one or more variables.

The calculator’s real-time updating function allows you to investigate how each variable affects the RWL and LI. If you know which variables can be altered to design a safer lift, enter the revised data. The RWL and LI calculations will update as each variable is changed.
Attachment 14 - Timeline for In-Class Study
(Note: “Self-directed” is referred to as “self study” in this report of the study findings.)

GO OVER AND ADJUST FOR #MINUTES//1HOUR TEST

Time-Line for Written Text or CD-ROM Self-Directed Group: First visit

1. Explain study Fact Sheet/Informed Consent and obtain informed consent. Ask them to both sign and PRINT their last name. (10 minutes)

2. Administer surveys in the following order: (22 minutes)
   - Pre-Training Subject Background Evaluation. (1 minute)
   - Technology Attitudes Evaluation (1 minute)
   - Knowledge and Skills Evaluation Tell to Start at FRONT and work straight through with no checking previous answers. If you don’t know the answer, make your best choice, but ANSWER ALL QUESTIONS. (20 minutes)

3. Distribute the written texts, and inform of the two addendums (5 minutes), and if a demonstration of CD is required (10 minutes).

4. Explain that there will be a comprehensive exam given for my final visit. (3 min.)
   - Study and be prepared to be tested on everything that is in the Text (Applications Manual for the Revised NIOSH Lifting Equation) including the two addendums (inserted at page 35), and the CD-ROM training program if they are using this condition.
   - This is a self-directed condition, and you are to receive NO help from your instructor.

TOTAL TIME FOR THE ABOVE IS 45 MINUTES

Time-Line for Written Text or CD-ROM Self-Directed Control Group: Final visit

Administer the exit survey and Knowledge and Skills Evaluation (20-30 minutes).
THE ABOVE IS A MAXIMUM OF 30 MINUTES