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Case study

Evaluation of in-plant ergonomics training

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Abstract

Plant personnel involved in a joint labor-management Ergonomics Pilot Project attended an introductory ergonomics course. The training was developed to provide trainees with the ergonomic knowledge necessary to perform their functions as part of the Ergonomic Pilot Project. A Train-the-Trainer program for Introductory Ergonomics was developed and implemented to provide Pilot Project plants with in-plant Introductory Ergonomics trainers. Trainee course satisfaction, ergonomic knowledge, and performance did not differ significantly for those trained by in-plant trainers compared to those trained by University instructors. This suggests that the Train-the-Trainer approach is a viable way of meeting the increasing demand for ergonomics training in industry.

Relevance to industry

The increase in reporting of work-related cumulative trauma disorders resulted in industry demand for ergonomic expertise to control these problems. A Train-the-Trainer program is an effective way of providing that expertise.

Keywords

Training, Train-the-Trainer, performance, evaluation, work-related musculoskeletal dsorders.

Introduction

As the incidence of reported cases of work-related low back and upper extremity musculoskeletal disorders increases in the United States (BLS 1990), as well as other countries, there has been an increasing emphasis on the need for in-plant ergonomics programs by regulatory agencies (OSHA, 1990), insurance companies, labor unions and companies (Parenmark, 1988). Since most industrial organizations have had little in-house ergonomics expertise, they have turned to outside 'ergonomic experts' or consultants. Those with ergonomic expertise have been hard pressed to meet the increasing demand by industry for their skills. One way of meeting this demand has been by offering ergonomics training programs to specific industrial groups (Rohmert and Laurig, 1977), or through university continuing educational courses for a variety of aspiring practitioners (Liker et al., 1990).

Recognizing the increasing demand for in-plant ergonomic knowledge and practice, and the increasingly scarce supply of trained ergonomics professionals, a joint union-management national committee on health and safety sponsored an ergonomics pilot project (EPP) to implement 'shop floor driven' ergonomics programs in four automotive plants. As part of that process, ergonomics training for different levels of the pilot project organization was developed, implemented and evaluated by University staff (UM) researchers. Development and testing of a 'Train-the-Trainer' approach (Robins and Klitzman, 1988) to provid-

ing on-going in-plant ergonomics training expertise is the focus of this paper. It was hypothesized that a TTT approach would be the most effective means for conducting the Introductory Ergonomics training.

Background

The organizational structure (figure 1) of the Ergonomics Pilot Project (EPP) was focused on the shop floor with the '*Ergonomic Monitor* (EM)', an hourly employee chosen by coworkers to attend 'Introductory Ergonomics' training. The EM's role was to conduct basic work area surveillance using Basic Job Checklists (Keyserling et al., 1990) to identify potential ergonomic problems on jobs in the work area, use symptoms questionnaires with co-workers to identify symptoms, develop simple solutions where applicable, or refer the problem on to those with more expertise in the organization. The Ergonomic Monitor (EM) was supported by his or her supervisor by being given time to analyze jobs for ergonomic problems, discuss problems and potential solutions. The EM and supervisor were supported by the Department Ergonomics Committee (DEC) which included the general foreman, union representative, area engineer and skilled tradesperson, as well as the supervisor/EM teams. The DEC was involved in discussing more complicated ergonomic problems and solutions beyond the 'quick fix' stage. The overall policy decisions were made by the Plant Ergonomics Committee (PEC) which included representatives from the plant manager's staff, union shop committee, health and safety, medical, engineering, maintenance and tooling. One union and one management fulltime Ergonomic Coordinators (EC) provided the essential links between all aspects of the organizational structure and provided the practical ergonomic expertise when needed.

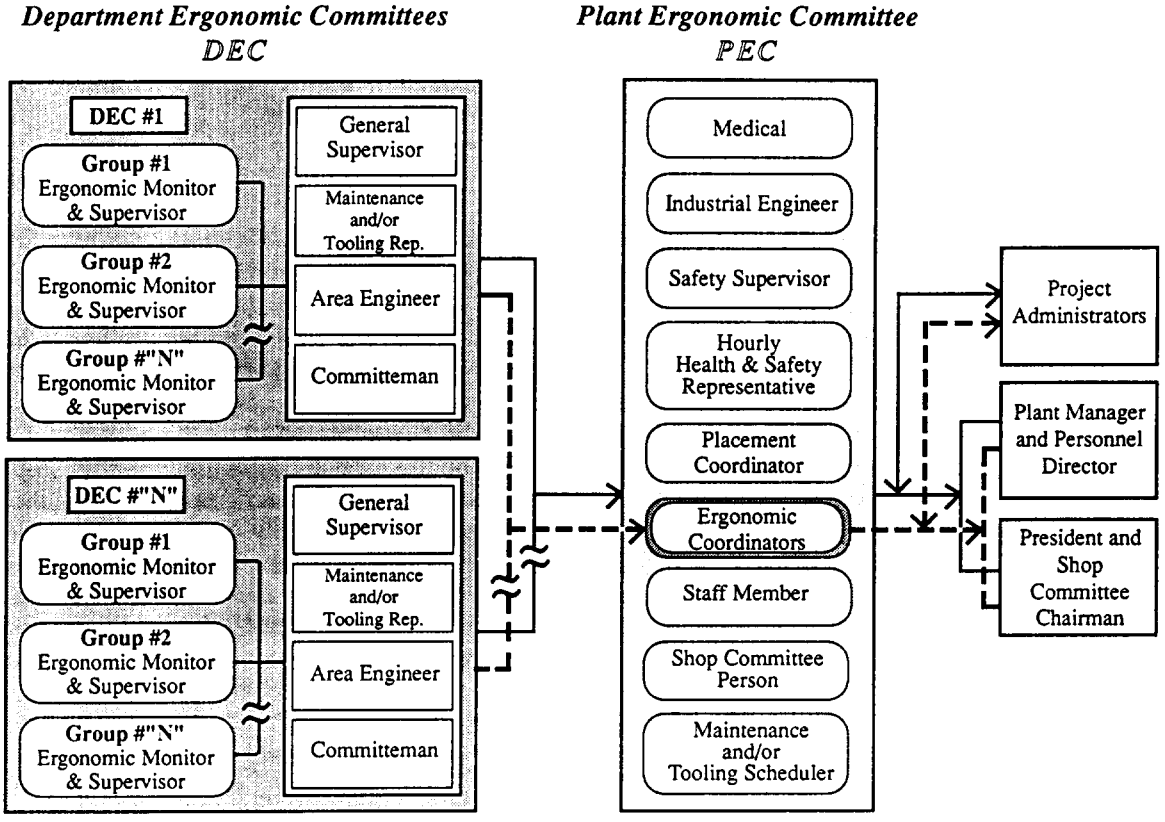


Fig. 1. Organizational structure of the ergonomics pilot project.

Ergonomics training

Intermediate ergonomics

Eight days of 'Intermediate Ergonomics' training provided by university instructors, similar to that described by Liker et al. (1990) was made available to the PECs, DEC engineers and skilled trades representatives and the Ergonomic Coordinators, with the goal of developing 'in-plant ergonomic experts' to serve as primary resources for the Ergonomics Pilot Project. Approximately 100 plant participants attended one of 5 courses.

Introductory ergonomics

The goal of the five-day Introductory Ergonomics course was to train Ergonomic Monitors and Supervisors to do 'Ergonomic Job Surveillance' by screening jobs for potential ergonomic problems and formulate solutions for problem jobs in their areas. This training was provided by university staff or in-plant trainers.

Participants included supervisors, hourly production employees (EMs), department union representative. Introductory Ergonomics course objectives were to enable participants to:

- Be familiar with the Ergonomics Pilot Project, its structure and goals, approaches to problem solving and its methods for identifying potential health hazards through the use of a Basic Job Checklist, and implementing change.
- Have a basic knowledge of ergonomics which will enable the participants to recognize problems related to posture, lifting, hand tools, repetitive motion, and general environmental conditions which affect employee health and performance.
- Have the skills necessary to analyze relatively simple ergonomic problems and formulate appropriate solutions.
- Be familiar with the Ergonomics Pilot Project forms (Basic Job Checklist, Postural Discomfort Survey, Symptoms Questionnaire, Documentation of Ergonomic Changes), how and when to use each form, and have sufficient practice to gain proficiency in their use and interpretation.

The first three days of the Introductory Ergonomics course were designed to be primarily conducted in a classroom setting. Trainees participated in exercises which provided them with the opportunity to analyze jobs either on videotape or on the plant floor, to develop proficiency in applying the knowledge gained through classroom lectures. During the final two days the instructors were to work with the Ergonomic Monitors on the plant floor while they analyzed the jobs in their area.

Ten training modules were developed to encompass the basic knowledge and skills required by the Ergonomic Monitors and Supervisors. The modules included

(1) Introduction to Ergonomics and the Pilot Project
(2) Problems and risk factors
  (a) Upper extremity cumulative trauma disorders (CTDs)
  (b) Low back disorders
(3) Controlling risk factors
  (a) Anthropometry and workplace layout
  (b) Workload, posture and repetitiveness
  (c) Hand tool design
  (d) Lifting and moving things (biomechanics)
(4) Workplace environment
  (a) Controls, displays and lighting
  (b) Noise and temperature
(5) Managing change and problem solving

Each module contained text material, design guidelines, appropriate Basic Job Checklist analysis techniques, and many of the visual aids used in the classroom presentation.

The Introductory Ergonomics training was piloted in three courses by university staff during the summer of 1987.

Train-the-Trainer program

A two-week Train-the-Trainer program (TTT) was taught by university staff in the late fall of 1987 to prepare in-plant trainers to effectively conduct the remainder of the Introductory Ergonomics training. Originally, there were 20 trainers who completed the program. The management trainers included safety supervisors, process engineer, and floor supervisors who were Ergonomic Coordinators. Hourly trainers included production workers and several skilled trades workers (some were Ergonomic Coordinators). Educational background ranged between less than high

school to university degree. All participants had extensive plant experience.

The objectives of the Train-the-Trainer program were:

- To provide trainers with the necessary skills to teach adults and provide sufficient practice teaching for the trainers to gain confidence in preparing and presenting the Introductory Ergonomics training materials.
- To prepare the trainers to work with the Ergonomic Monitors on the plant floor during the two-day job analysis which follows the classroom training.
- To prepare the trainers to constructively evaluate their course evaluations and modify their teaching techniques as needed.

The principles for training high-performance skills developed by Schneider (1985) were adopted in the design of the TTT course manual. Active participation of the trainees was encouraged throughout. Technical aspects of ergonomics were blended with strategies for change and methods of teaching, to maximize understanding of the interrelatedness of the components of the project. University instructors modeled the use of various training methods.

The trainers also received additional sessions in preparing and conducting training sessions, teaching adults, team teaching and constructive review of course evaluations. Practice teaching sessions and workshops on the plant floor provided the skills they needed to conduct the Introductory Ergonomics training. Trainers used about one month in their respective plants to adapt the training to the local plant environment.

Training evaluation methods

Evaluation of Introductory Ergonomics training was focused on (a) training process, (b) trainee competence (ergonomic knowledge), and (c) performance. These parameters were used to compare training taught by

(a) in-plant trainers (TTT) and

(b) university staff (UM).

Secondly, follow-up performance on basic job checklists was compared between those who participated in the Introductory Ergonomics course with those who participated in the Intermediate Ergonomics course.

A pre-post training and follow-up approach was used to evaluate the training programs. Questionnaires were used to assess participant perceptions of the training. This was supplemented by post training group interviews with Trainers and Ergonomic Monitors. Quizzes were used to assess ergonomic knowledge (Joseph, 1986; Liker, 1990). Basic Job Checklists (BJCs) on videotaped jobs were used to assess performance. University staff observation was used to evaluate the performance of in-plant trainers in Introductory Ergonomics. Those questionnaires and quizzes without identifiers (last 4 digits of social security number or name) were excluded from the analyses because direct pre-post comparisons could not be made.

Process

Trainee Acceptance was assessed by brief end of each day *Questionnaires* (five-point scales) addressing trainee perceptions of each subject or module: prior interest in the subject, post interest, how much was learned and how satisfied they were with the presentation of subjects.

Analysis of variance was used to test the hypothesis of no difference in participant acceptance based on educational level. Paired t-tests were used to compare pre versus post interest in the topic taught. Student t-tests were used to compare process between TTT taught and UM taught Introductory Ergonomics.

The 'Managing change' module was not formally evaluated in the University taught courses. Observation of the Trainers teaching the module during their first or second course was done to observe content and process in a more qualitative way.

Ergonomic knowledge

The Ergonomic Knowledge Assessment Quiz comprised (1) slides that participants rated on level of stressfulness based on posture, load and frequency; (2) true–false and (3) multiple choice questions. The quiz was administered prior to training, at the end of training, and in June–July 1988 (anywhere from 3–13 months after initial

training). The quiz had four slightly different versions over the course of the training and follow-up testing. For purposes of comparison, only those parts of the Quiz that were consistent over the course of training were used in the evaluation process. There were no questions addressing the 'Managing change' module.

Quiz scoring procedure

Slides were standardized to have the correct answer of zero and the absolute number from zero was used as the score for an individual slide. The mean of these standardized scores was taken for back, shoulder, and wrist slides separately. True–false and multiple choice *questions* were grouped into the subject areas of the training (with some overlap of questions possible) and also standardizing the correct answer to equal zero. The questions relating to the same subject area were then summed.

Analysis of variance was used to compare quiz scores by training type, by position in the Ergonomics Pilot Project, and by education level. Paired *t*-tests were used to compare pre-training scores to post-training scores, pre-training to follow-up scores, and post training to follow-up scores.

Performance

Originally we anticipated being able to compare Basic Job Checklists (BJCs) completed by the Ergonomic Monitors to those completed by instructors during the training process, or to graduate students and 'ergonomic expert' ratings of 10 jobs. In actual practice, different products were often running when jobs were analyzed at different times. These changes potentially altering estimates of force, posture and repetitiveness characteristics. Therefore, in order to standardize observations, two videotaped jobs (from non-pilot project plants, 'load housings', and 'O-rings') were used for Introductory Ergonomics training participants to complete in June–July 1988. BJCs completed by UM instructors were used as 'the gold standard'. Analysis of variance was used to test difference in percent correct BJC scores by training type (Hicks, 1973; Montgomery, 1984).

Results

Participation

The training and evaluation time-table is presented in table 1. The three UM-taught Introductory Ergonomics courses took place in the summer of 1987 when very little of the Pilot Project structure was in place. Of the 34 participants in the three UM-taught Introductory Ergonomics courses, 32 completed pre-interest surveys and 27 completed most of the post-module questionnaires. DEC members (excluding EMs) were often called out of class for differing periods of time.

Additionally, the supervisors were not present after the third day of the training to receive the post-quiz and evaluate the last day of the course. This is because they were not required to perform the activities of that day, completing Basic Job Checklists and Symptoms Questionnaires.

Of the 27 participants in the four in-plant trainer-taught Introductory Ergonomics courses evaluated, 25 completed most of the post-module questionnaires.

Completion of the various Ergonomic assessment quizzes is presented in table 2. Loss at follow-up was primarily a function of plant layoffs and transfers.

The Introductory Ergonomics Train-the-Trainer program was conducted during November 1987. By the time the TTT Refresher Course took place in April 1988, 14 of the original 20 trainers were able to participate. The other six had been laid off

Table 1

Training and evaluation timeframe

Jun–Aug 1987	University-taught introductory ergonomics
Nov 1987	Train-the-Trainer course
Feb–Apr 1988	TTT-taught introductory ergonomics
Apr 1988...	TTT 'refresher course'
Jun 1988...	Follow-up quiz, performance evaluation
Jan 1989...	Ergonomic monitor 'refresher course'

Table 2

Completion of ergonomic assessment quizzes by training type

	Pre-train	Post-train	Follow-up
Introductory UM	31	25 (81%)	14 (45%)
Introductory TTT	27	25 (93%)	15 (56%)

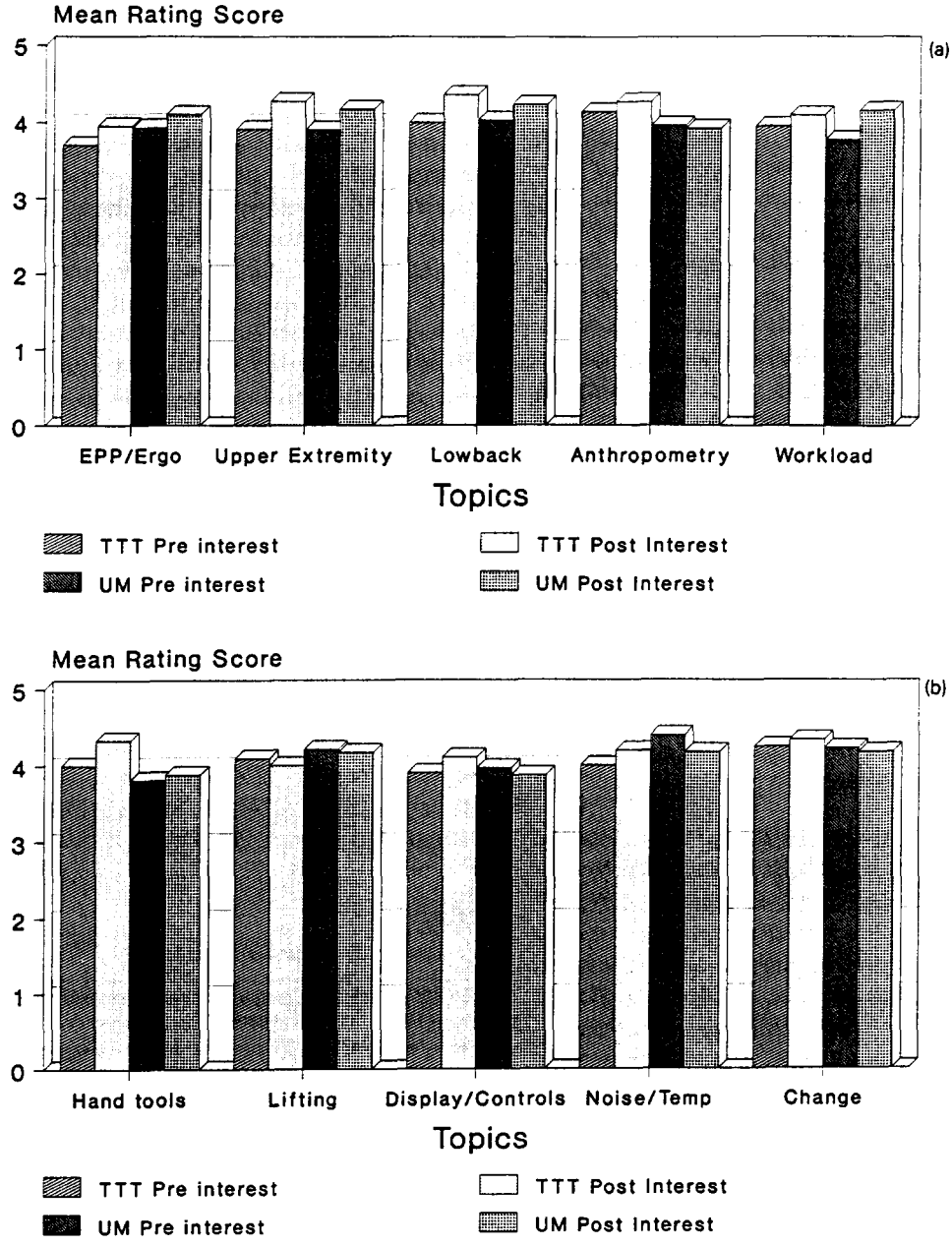
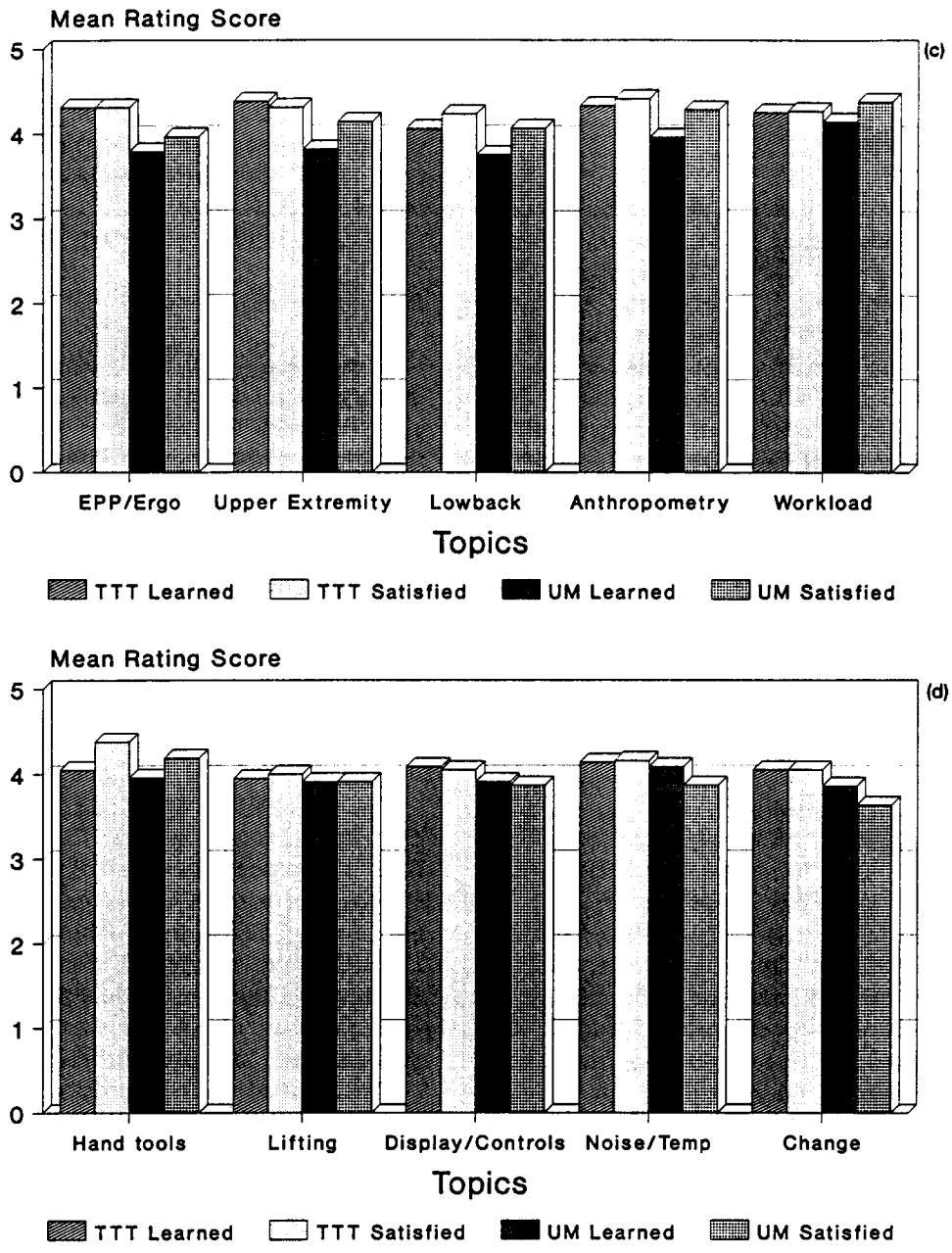


Fig. 2. Process by training type and subject: (a) Pre- and post-training interest scores for: Ergonomics Pilot Project, upper extremity cumulative trauma disorders, low back disorders, anthropometry, workload (TTT: Train-the-Trainer-taught, UM: University-taught); (b) Pre- and post-training interest scores for: hand tools, moving and lifting things, displays and controls, noise and temperature, managing change; (c) Amount learned and amount of satisfaction with training in Ergonomics Pilot Project, upper extremity cumulative trauma disorders, low back disorders, anthropometry, workload; (d) Amount learned and amount of satisfaction with



TTT:n=21, UM:n=25, (excl DK)

Fig. 2 (continued).

or transferred and had no ongoing relationship to the Ergonomics Pilot Project.

Process

Although TTT trainees tended to rate satisfaction higher than UM trainees, there were no significant differences in participant assessment of the courses taught by the trainers and by UM (figures 2a–2d) in terms of pre-interest, post-interest, amount learned or satisfaction with the training. There were no significant differences in pre- versus post-training interest in any of the modules for either group. In all cases, interest and satisfac-

tion were rated quite highly. This suggests that the in-plant trainers had gained the necessary credibility as 'ergonomic experts' with trainees.

Ergonomic knowledge

There was no statistically significant association between pre-interest and test score by topic area. There were no statistically significant differences (student *t*-test) in pre- and post-quiz scores between the TTT trained and UM-trained participants with respect to slide scores or most of the topic question summary scores (figures 3a–3c). However, the UM-trained group had significantly worse summary scores on the pre-test for module (3a) (anthropometry) and module (3d) (moving and lifting things) ($p < 0.05$).

Anthropometry appeared to be difficult for the TTT-trained group. When the post-training score was subtracted from the pre-training score, there was a significant difference ($p < 0.05$) between the two groups where the TTT-trained group had a worse score and the UM-trained group had improved (-0.6 vs. 1.0). Small numbers who took the follow-up quiz precluded statistical testing.

Improvement between pre- and post-training summary *slide scores* (evaluating stress on the low back, shoulder and wrist) were not statistically significant for the TTT-trained participants, although improvement in wrist score was of borderline significance ($p < 0.06$). There was significant improvement for both back and wrist slides ($p < 0.05$) for UM-trained participants, figure 3a. Although improvement over pre-training scores was present at follow-up for both groups, it was not statistically significant ($n = 14$ for both groups).

Summary *question scores* by topic area indicated TTT-trained participants showed statistically significant improvements with training in upper extremity cumulative trauma disorders (module (2a), $p < 0.000$), low back (module (2b), $p < 0.05$), workload (module (3b), $p < 0.001$), hand tools (module (3c), $p < 0.01$), and controls and displays (module (4a), $p < 0.01$). Statistically significant improvement was seen in the same modules by UM-trained participants, with borderline significant improvement in anthropometry (module (3a), $p < 0.08$) and moving and lifting things (module (3d), $p < 0.07$), figure 3b.

Statistically significant improvements between pre- and post-training were seen in the same areas for the TTT-trained group. However, only four and three individuals answered all the questions related to modules (3a) and (3d) so no comparison was made. Among the UM-trained group, statistically significant improvements were maintained in modules (2a), (2b), (3b), and (4a) with borderline significance in (3d) ($p < 0.07$), figure 3c.

Performance at follow-up

During June–July 1988, participants in Introductory Ergonomics, Intermediate Ergonomics and Train-the-Trainer were requested to participate in a follow-up evaluation during which they completed the Ergonomic Assessment Quiz, a short questionnaire about their role in the Ergonomics Pilot Project and opinion about adequacy of training, and two Basic Job Checklists (BJCs) on videotaped jobs (in non-Ergonomics Pilot Project plants), after being given certain production and environmental information about the jobs.

Participants and perceptions

One hundred forty-six participants completed the follow-up questionnaire. The mean number of BJCs completed since initial training was 5.6 (range from 0 to 90). This varied by plant and role. Among Ergonomic Monitors, an average of 23 BJCs were completed, compared to 20 for Ergonomic Coordinators, less than one for DEC PEC members as well as those with no formal role, and less than three for trainers.

When asked 'Do you think the ergonomics training you received was adequate to prepare you for your role in the Ergonomics Pilot Project?', 55% indicated YES, 7% indicated NO, and 38% were NOT SURE. The responses varied by role in the Ergonomics Pilot Project (table 3).

Performance on basic job checklist

One hundred thirty-two participants completed BJCs on 'Job 2' (load housing) and 138 completed BJCs on 'Job 1' (O-rings). Answers were compared to those of 3 UM 'experts' analyzing the same videotapes. In general, participants did quite well on both jobs. For example, on Job 1, the average percent of correct answers ranged from

78% overall on the upper extremity checklist to 98% on the metabolic checklist. On Job 2, average percent correct answers ranged from 77% on the manual lifting checklist to 98% on the metabolic checklist.

With respect to posture (figures 4a and 4b), there was difficulty in distinguishing mild from severe trunk flexion, but most participants agreed that trunk flexion did not occur longer than 1/3 of the cycle. Most did not correctly identify neck extension and twisting that occurred for less than 1/3 cycle. This may be due to the two-dimensional nature of videotapes or the difficulty in estimating more than 20 degrees of extension without the advantage of stopping the video to actually measure angles.

Upper extremity checklists were problematic for many participants. While 97% recognized that both jobs were repetitive (figure 4c), many seemed to be confused about 'subcycle'. There were two ways a job could meet the repetitiveness criteria: (1) less than 30-second cycle time (which was true for both jobs), or (2) a subcycle (series of motions which repeat themselves within a cycle) lasting more than 50% of the cycle time (which was true for neither job). In a revised checklist, these two criteria have been combined into one question. However, the definition of subcycle still needs to be more clearly explained in the training.

BJC performance and training

Thirty-four individuals attending the 5th Intermediate Ergonomics Course completed a Basic Job Checklist on a videotaped 'door hang' job prior to receiving any training. The job was similar in types of risk factors to the 'load housing' job, and like that job, was not from one of the 4 Pilot Project plants. Results from this group (mean percent correct by checklist) were compared to results of those who completed the 'load housing' BJC on follow-up, 3–13 months after their training.

A two-way analysis of variance, fixed effects model, with two-way interaction used as error term was used for tests of significant difference in mean percent correct answers (dependent variable) by checklist. The 'load housing' job was used for 6 groups with training, and the 'door hang' job was used for the group with no training. The independent variables were the Checklists: Environment, Posture, Metabolic, MMH, Upper extremity. The Groups were: Ergonomic Monitor (EM), Ergonomic Coordinator (EC), Department Ergonomics Committee excluding EMs (DEC), Plant Ergonomics Committee excluding ECs (PEC), Trainers excluding ECs, No formal EPP role (other), No formal training (None).

Overall, there was a significant difference between groups at $p < 0.000$, table 4. Those with training had a significantly higher mean percent correct than the group with no training at $p < 0.001$. EC's and TRAINER's had a significantly higher mean percent correct than did the EM's and DEC's at $p = 0.05$.

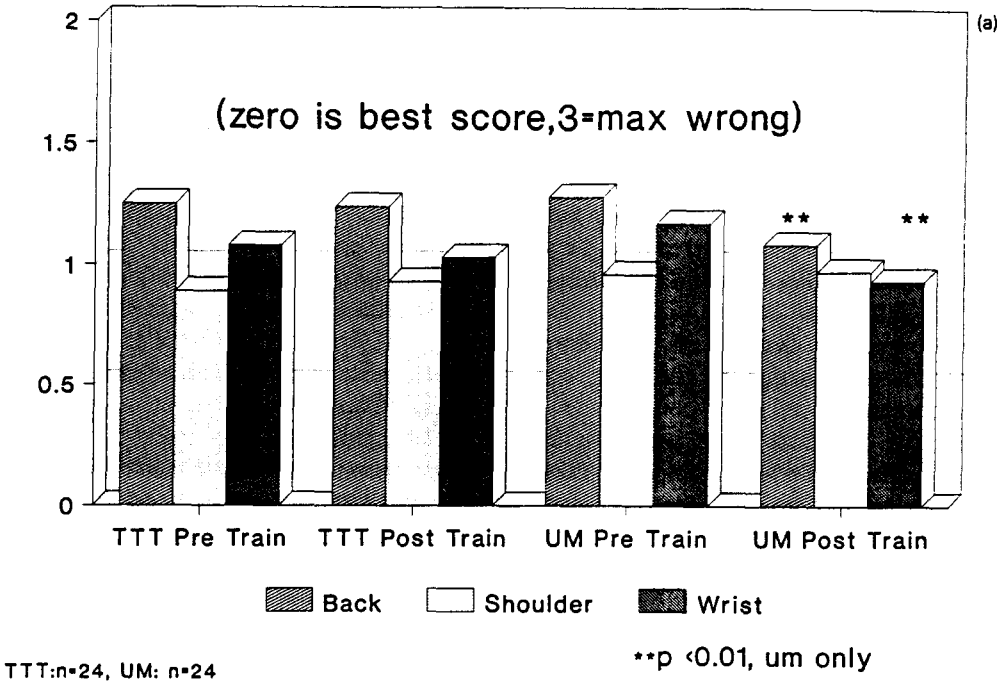
The group with no training consistently had lower percents of correct answers for all checklists with the exception of PEC on the Posture checklist. There was a significant difference between checklists at $p < 0.000$, table 5.

Discussion

The results indicate that Introductory Ergonomics was well received by trainees and that, in general, ergonomic knowledge increased as a result of the training. Retention of ergonomic knowledge is strong in most areas, particularly with use of the knowledge. Additionally, Train-the-Trainer is an effective and viable approach to transferring introductory level ergonomic knowledge to the plants with in-plant trainers.

Development and implementation of the training programs, and their evaluation, took place during very difficult times for the Pilot Plants, and when much of the the in-plant organizational apparatus for being able to take advantage of the training was still being developed. At the same time, institutional relationships between those from the plants, the Pilot Project administration and the University researchers were also being developed. Thus, the results may indicate the least one could expect from these training programs.

The results must be viewed in the context of (1) the external environment, (2) limitations in participation and sample sizes for evaluation purposes, and (3) limitations of the evaluation methods themselves.



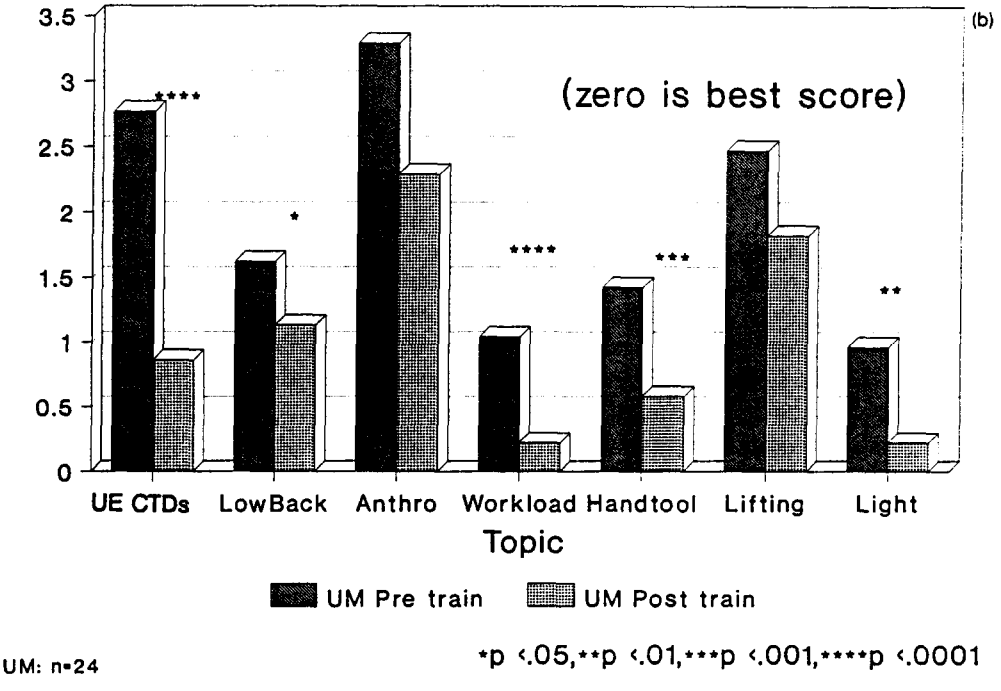


Fig. 3. Ergonomic knowledge by training type and subject: (a) Pre- and Post-training quiz slide scores for back, shoulder and wrist stressors; (b) UM-trained pre- and post-training quiz topic scores (note: UE CTDs – upper extremity cumulative trauma disorders); (c) TTT-trained pre- and post-training quiz topic scores (note: UE CTDs – upper extremity cumulative trauma disorders).

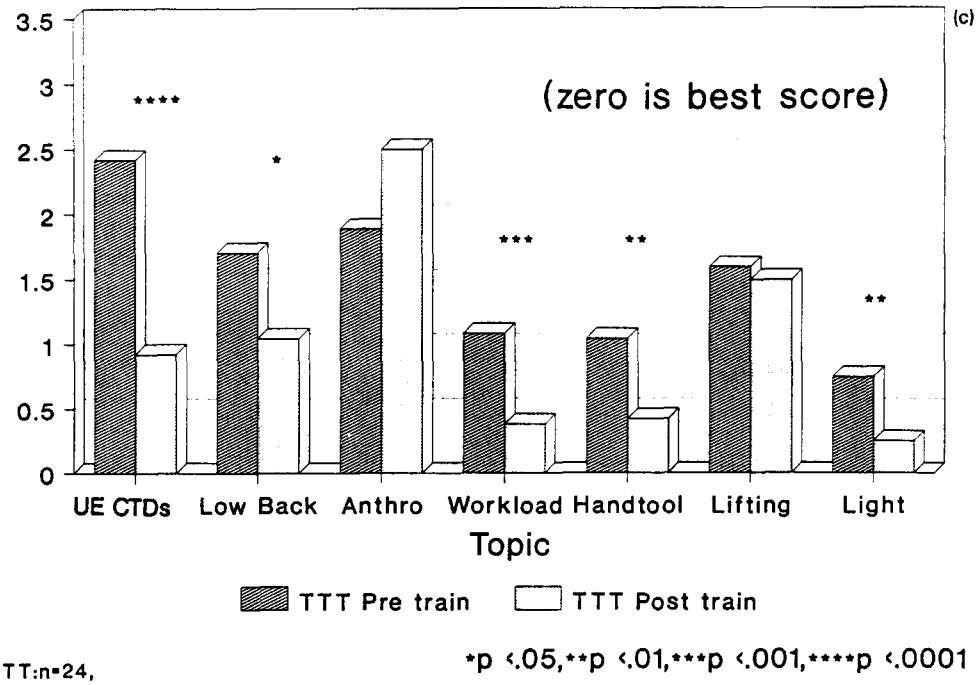


Fig. 3 (continued).

Ergonomics, the environment and change

Clearly, ergonomics training does not occur in isolation from the plant environment, perceived support for using the training, previous history of implementing other programs which also required some training (Joseph, 1986). Recognizing this process, the University staff training team included 'managing change' in both the Intermediate and Introductory Ergonomics (Module 5) courses. In the 'process' daily evaluations by trainees, there were high scores on interest, learning and satisfaction with this component. Yet, in both TTT and Ergonomic Monitor Refresher sessions, this was identified as the area of greatest discomfort and need.

Table 3

View of ergonomic training by ergonomics pilot project role, at follow-up 6–7/88

Role	(*n*)	Training adequate		
		Yes	No	Not sure
Ergonomic monitor	25	36.4%	13.6%	50.0%
Ergonomic coordinator	9	55.6%	11.1%	33.3%
Dept. ergonomics comm.	33	70.0%	6.7%	23.3%
Plant ergonomics comm.	12	75.0%	8.3%	16.7%
Trainers	6	80.0%	0.0%	20.0%
No formal role	59	50.0%	5.5%	43.6%

Module 5 was unique. Unlike the rest of the Introductory Ergonomics course, there was nothing about 'ergonomics'. The contents of the module fell into two conceptual categories, strategies for change and problem-solving. The presentation of this module relied on some awareness of organizational development, group dynamics, personality types and political sensitivity. We included this material because the social and political aspects of implementation are often the critical determinants of success for any innovative project. Module 5 teaches the use of multi-faceted cooperative methods compatible with the philosophy of progressive joint programs, of which the Ergonomic Pilot Project is one example.

Although the module was designed to address strategies for problem-solving and implementing change, it did so outside the context of the plant environments in which the trainers and trainees had to operate. While trainers agreed that this module was important, and after teaching at least one session, believed it should be expanded, they were critical of the module as it was presented in

the TTT course. The most frequently expressed criticism was that the module was too abstract and in need of plant specific examples.

Trainer discomfort with presenting the Managing Change module also seemed to be related to bureaucratic problems within the plants and perhaps most challenging, the negative attitudes of many trainees toward the possibility of solving problems. Ergonomic monitors felt ill-equipped to go through the problem-solving process in attempting to implement their ergonomic changes. The frustrations associated with implementation have been expressed at all levels of the Pilot Project. This suggests that training in these change

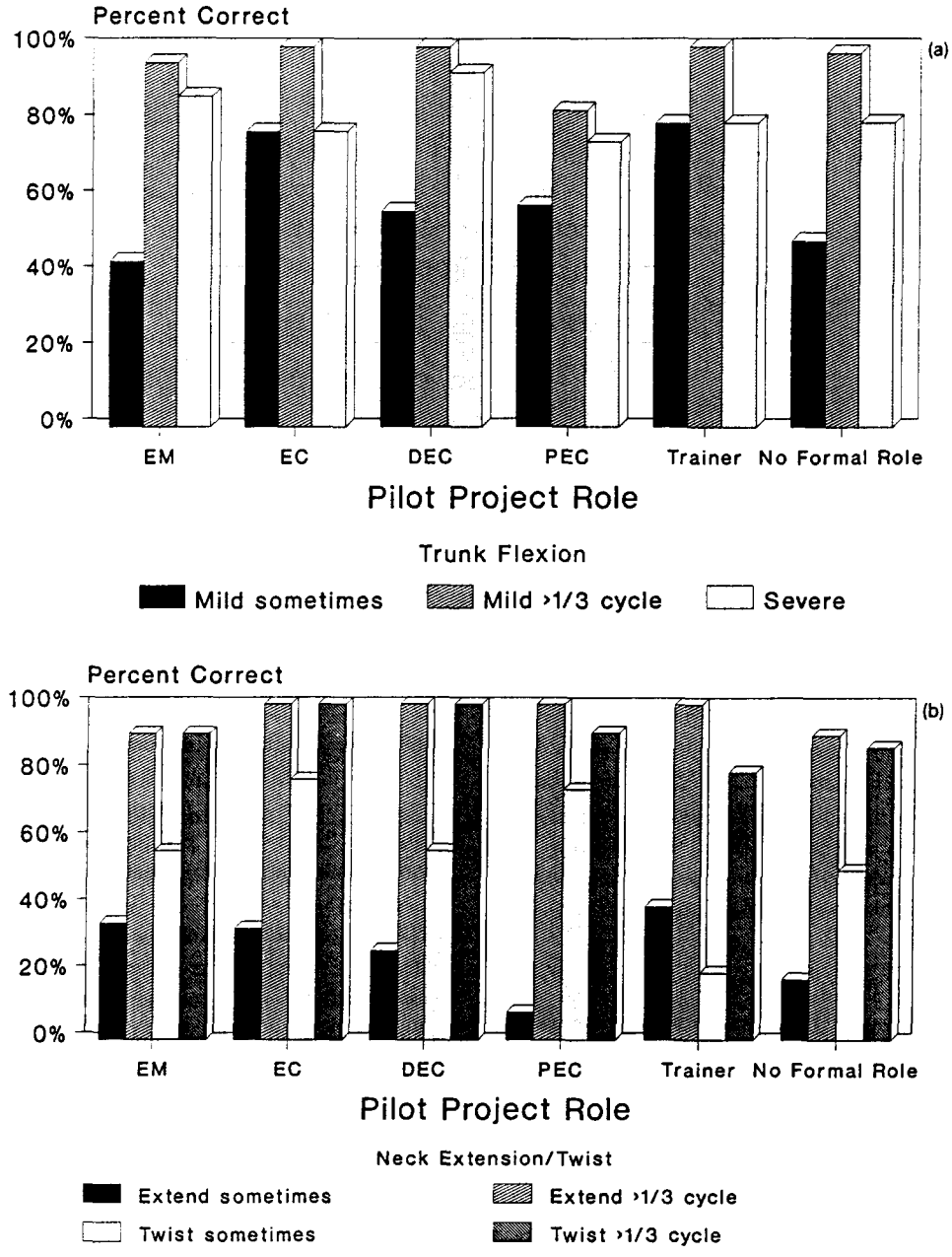


Fig. 4. Percent correct answers on Selected Problematic Basic Job Checklist Questions by EPP role at follow-up: (a) Trunk flexion on Job 1, $n = 134$; (b) Neck extension and twisting on Job 1, $n = 134$; (c) Repetitiveness on Job 1 and Job 2, $n = 134$.

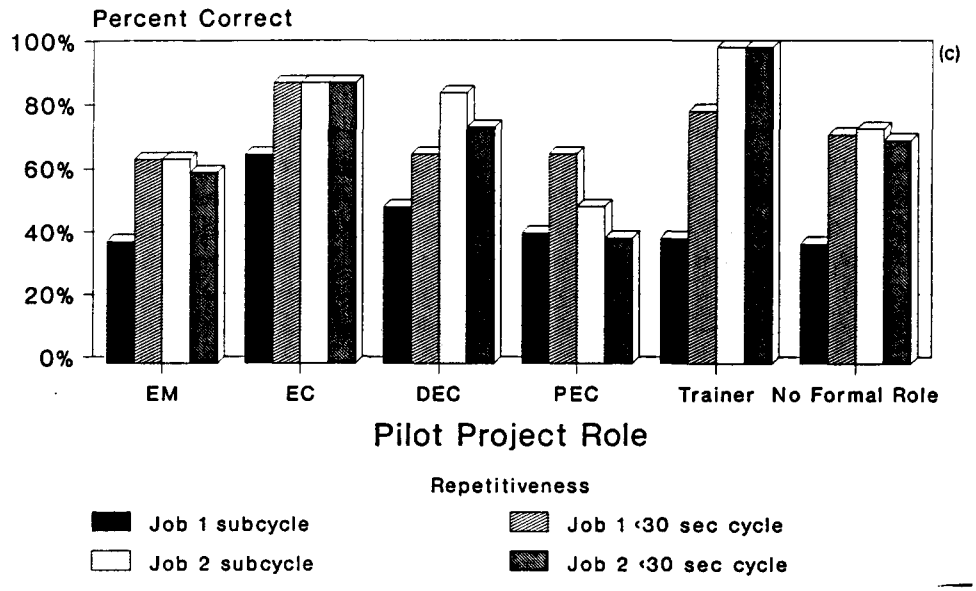


Fig. 4 (continued).

strategies is a critical component of ergonomics training, but that as yet, the best way to do it has not been determined. The use of simulation training in this context should be explored (Shepherd. 1986).

The focus of the ergonomics training was on

Table 4

Percent correct answers on BJCs by group: orthogonal contrasts

	Trainer	EC	EM	DEC	Other	PEC	None
% Correct	91.7	89.7	86.7	86.7	85.7	83.0	74.0
Contrast						*F*-stat	
Trainer + EC + EM + DEC + Other vs. None						46.27 [c]	
Trainer + EC + PEC versus EM + DEC						< 1.0	
Trainer + EC versus EM + DEC						4.26 [a]	

[a] $p < 0.05$, [b] $p < 0.01$, [c] $p < 0.001$.

Table 5

Percent correct answers for each group and checklist

Group	Checklist				
	Environment	Posture	Metabolic	Materials handling	Upper extremity
EM	85.4	87.6	96.8	81.5	82.2
EC	92.9	92.3	95.8	78.9	88.6
DEC	86.0	89.3	96.9	78.1	83.2
PEC	82.7	83.1	98.8	70.8	79.4
Trainer	93.9	91.0	97.9	90.5	85.2
Other	86.0	88.7	98.6	73.6	81.8
None	66.2	86.3	84.6	61.3	71.8

identification and control of physical stresses in the workplace to reduce musculoskeletal problems. Work organization issues were touched on only in terms of reducing the repetitiveness of the job. Due to time limitations and other priorities, little attention was directed toward work organization and reduction of mental stressors as potential contributors to musculoskeletal disorders, and enhancement of working life. This is a particularly important area for future ergonomics training as workload shifts from physical demands on large muscle groups to increased load on small muscle groups and cognitive loading.

Participation in ergonomics training

The integration of supervisors into the shop floor ergonomic surveillance process (DEC) through training had not been well thought out when the UM Introductory training began. Supervisors were not required to participate in the last two days of the course where BJCs and Symptoms Questionnaires were completed in the department. Had the supervisors been required to analyze jobs in their own department (rather than just having the EMs do it), they might have become more familiar with the risk factors on jobs in their area, recognize the importance of the EMs in monitoring jobs, and facilitate the implementation of ergonomics changes (Smith, 1984; Mager, 1984). This problem was recognized by the Ergonomic Coordinators and Trainers almost immediately. They began to include the supervisors in the entire course.

Evaluation tools

Evaluation of ergonomic knowledge was based on pre-post training quizzes which included slides of jobs, true–false and multiple choice questions. The quiz is probably most useful in evaluating general ergonomic knowledge. The quiz was based on an instrument developed in the course of research on ergonomics programs in another organization (Joseph, 1986). Some questions changed between the UM-taught versus the TTT-taught Introductory Ergonomics. This reduced the number of items that could actually be compared between different types of training and different time periods.

While all questions were related to occupational ergonomics per se, they were not targeted to insuring that main points were covered within each module in Introductory Ergonomics. An example might be asking questions about cycles and subcycles to insure that the concept of evaluating repetitiveness was understood. Competency exams after each module and then at the end of the training period would have provided earlier feedback about lack of knowledge transfer (Smith and Merchant, 1990). There were no questions on problem-solving or implementing change strategies. This makes it difficult to determine where the problems in the transfer of information were taking place.

With respect to evaluation of performance, the original intent was to compare BJCs completed by Introductory Ergonomics participants to those completed by 'experts'. However, changes in the work, and other logistic problems, precluded a systematic comparison. The use of videotaped jobs for this purpose at least standardizes what is observable. However, videotapes are two-dimensional and this limits one's ability to view the job from all angles and over time. An alternative might be to simulate a job for trainees to evaluate. If the same job simulation is used across courses, evaluation across classes could be done.

Retention of ergonomic information in evaluating jobs for risk factors was quite high. As expected, those who used the job checklists demonstrated better performance than those who had not.

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