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Comparison of training hard copy and computer job-aids: using expert object technology

Ronald Herbert Gibson

To the Graduate Council:

I am submitting herewith a dissertation written by Ronald Herbert Gibson entitled "Comparison of training hard copy and computer job-aids: using expert object technology." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Human Ecology.

Walter A. Cameron, Major Professor

We have read this dissertation and recommend its acceptance:

John Peters, Clifton P. Campbell, Dudley Dewhurst

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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and recommend its acceptance:

Clifton P. Campbell

Accepted for the Council:

Associate Vice Chancellor and
Dean of the Graduate School

Comparison of Training Hard Copy and Computer Job-Aids: Using Expert Object Technology

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Ronald H. Gibson

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Abstract

The purpose of this study was to develop a computer job-aid for industrial trainers from a hard copy version using an object-based expert-system, and to test the effectiveness of the resulting training process against the traditional paper version. The objectives allowed for this development, pilot-testing of the expert computer job-aid, and comparison of the computer job-aid for: (a.) content understanding and use, (b.) completion time, and (c.) participants' satisfaction.

Computer programming methods allow flow chart, and procedural development in the object paradigm. These methods closely resemble problem solving methods used for diagnostics and traditional job-aids. Training methods also allow for the use of holistic computer methods together with traditional training development. Logically, if the two methods are similar then the results of the application should be similar.

A posttest only quasi-experimental design was used to compare results of the posttest to the objectives to demonstrate effectiveness of the two methods of training. Two groups of 12 professional persons were taken from industry in North East Tennessee. Twelve took the traditional paper instruction and 12 took the expert computer job-aid. The results indicate that both methods worked equally well. Neither method had an advantage. The paper method took less time to administer and the computer method was better perceived by the user.

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Chapter I

Introduction

Computerized artificial intelligence whether future reality or past fiction has been the center of applications research. Expert-systems include knowledge-based systems (KBS) (Headberg, 1993) and they are the best known of all artificial intelligence (AI). Record shows some companies have invested significantly in this technology. While the returns may be significant there are risks in time and money (Krovvidy, 1999).

Applications of AI for information processing focus on knowledge management using expert-systems together with object-technology. The expert system alone may either provide direct training (Martin, Subramanian, Yaverbaum, 1996; Krovvidy, 1999), electronic learning or an electronic aid (Job Aid) to job performance (Oxman, 1989, pp. 1-24). Grady Booch (1994) as a chief scientist in the development of applications using object methods for Rational Software Engineering Solutions said, "Developments in knowledge representation have contributed to an understanding of object oriented abstractions" (p.37). Minsky proposed frames to represent real-world objects in 1975, through perception by image and natural language recognition. Now a variety of intelligent computer systems have implemented frames as their architectural foundation. Knowledge management includes people, procedures, hardware, software, data, and knowledge, for machines that demonstrate intelligence as an attempt to make machines do tasks that previously only people could do (Wenn, 1999).

Two systems are found, the expert system and the knowledge-based system. Generally speaking, the expert system is computer software that models human expertise in a structured active environment, including data base, inference engine, and computer based program development (Headberg, 1993). The knowledge-based system, use existing knowledge structure, may or may not use an inference engine, and may not be able to derive new knowledge. Pure expert systems can implement all of these. Expert systems work together with object technology and multimedia to form functional computer applications. The expert system provides intelligent storage, indexing, retrieval, and distribution (Headberg, 1993). Object technology simplifies the process.

A separately used tool, CASE-based-reasoning (Computer Aided Software Engineering (CASE), is now being imbedded in the expert system. CASE tools provide interactive helps, cross-indexing of files, and information retrieval (Headberg, 1993; SHAI, 1999).

Research indicates that formal learning situations may provide individuals with an understanding of facts but the capability to use the information may be missing. This type knowledge may be called inert (Lajoie, & Lesgold, 1992). Additionally, due to the rapidly expanding knowledge requirements in technical society, item-specific, in-depth knowledge may be largely impossible for the majority audience (Kepler, 1993).

Statement of the Problem

Literature shows that the object-based expert system provides opportunity for the user to cope with the application and management of knowledge. Unfortunately, there is a lack of comparative information about knowledge application solutions using expert systems and object-based technology software to collaborate or compare to other approaches. While the efforts may be effectively documented studies are lacking.

Purpose of the Study

The purpose of this study was to develop a computer job-aid for industrial trainers from a hard copy version using an object-based expert-system, and to test the effectiveness of the resulting training process against the paper-based (hard copy) version.

Rationale

Object technology is a major shift in computer paradigms. Object technology allows complex (real world) representations. Information may be used in forms of objects such as

1. Parts illustrations
2. Video clips
3. Sound bites

Consequently, object technology is expected to acquire a niche with computer training and support systems (Servio Corp., 1993). Expert systems in turn are thought to contribute to critical skills in mentoring or learning (Krovvidy, 1999).

When learning many individuals gain an understanding of facts but are incapable of using the information for constructive purposes to understand the difference between the physical world and their facts (Lajoie & Lesgold, 1992). Intelligent beings are supposed to acquire and retain knowledge from experience then use reasoning to respond to new situations to solve problems (Wenn, 1999). Traditional educational methods may not provide links between subject and job task performance. Therefore "inert knowledge" is observed much too often (Lajoie & Lesgold, 1992).

Military use of computer training programs engage "inert knowledge" to present information along with the ability to apply it on the appropriate occasions (Lajoie & Lesgold, 1992; ISD, 1993). Other institutions have successfully developed computer training to provide both knowledge and skills using similar methods. Additionally trainers have successfully implemented instructional computer programs that

1. Allow active participation

2. Provide application

3. Unlock knowledge for a better understanding

(Pautler, 1971, pp. 101-123).

Historically, instruction was one on one; personally conducted between a master and apprentice. Today, the one on one relationship is missing. Expert systems with object technology may assist dissemination of information through an interaction process like the master and apprentice.

Objectives

The objectives of this study were to

1. Develop a computer job-aid for instruction of industrial trainers, using an object-based expert system

2. Pilot-test operation of the computer job-aid

3. Compare the developed computer job-aid with the standard paper-based (hard copy) job-aid for (a.) content

understanding and use, (b.) completion time, and (c.) participant satisfaction

Theoretical Base

Object technology and expert systems are mutually dependent on one another for achieving effective applications (Headberg, 1993). Together they allow complex (real world) expert information represented in the form of objects (Booch, 1994, pp. 27-80). This merging of human knowledge through intelligent systems is a major shift in the computer paradigm (Farr & Psotka, 1992; Frogner, 1992).

Many close interrelationships exist between object technology and expert systems as contrasted with technical training, adult education, systems theory and knowledge engineering (Booch, 1994; Boone, 1985; Department of the Air Force, 1993; Oxman, 1989; Senge, 1990; and Taylor, 1993). These shared traits allow opportunity for effective applications.

The coupling of object technology with expert systems increases their potential and reduces limitations. Development time reduces, and software modules become reusable. Also, software becomes more affordable than with previous research developments (Booch, 1994, pp. 268-290; Kepler, 1993).

Since 1980 the application expert systems technology has not achieved the use expected (Uhrig, 1994). Without custom modification, the resulting products were not reusable (Servio Corp., 1993). Literature does not suggest whether this technology also experienced the knowledge development problems encountered by trainers, adult educators, knowledge engineers, etc. The greater problem voiced by Servio (a major developer of data-base systems), and later by Krovvidy says "effectiveness was limited by the time of development (labor intensive), cost of production, and cost of software" (Servio Corp., 1993, p. 5; Krovvidy, 1999).

Traits have been identified that help reduce limitations of object-based expert systems, these are

1. Use of a knowledge-base derived from subject authority or heuristic expert (Krovvidy, 1999; Milheim, 1990; Oxman, 1989)

2. Task development in the knowledge-base (Krovvidy, 1999; Lajoie & Lesgold, 1992)

3. Intelligent graphics

4. Object system methods (Booch, 1994; Katz, Lesgold, Eggan, & Gordin, 1993)

5. Cost effectiveness of implementation (Erman, L., Lark, J., & Hayes-Roth, F., 1988; Uhrig, 1994)

6. Reduced complexity (Steve Kennedy (personal interview, July 6, 1994); Taylor, 1994)

7. Flexibility

8. Efficiency

9. Easier maintenance

10. Reduced technical problems (Oxman, 1989; Taylor, 1993)

11. Nonlinear

12. Branching methods (Shute & Psotka, 1994; Taylor, 1993)

13. Interactivity (Booch, 1994; Milheim, 1990; Oxman, 1989)

14. Exploratory nature & path tracing (Erman, Lark, & Hayes-Roth, 1988; Milheim, 1990)

15. Self-documentation (Oxman, 1989)

16. Goal orientation

17. Use of subsystems (Erman, Lark, & Hayes-Roth, 1988)

18. Knowledge resource allocation for information tracking & presentation methods

19. User and system information, presentation, & tracking methods for approximation of the ideal (Erman, Lark, & Hayes-Roth, 1988; Milheim, 1990)

20. Apparent intelligence (Fink & Herren, 1991)

21. Modeling of human thought -- expert and learner (Katz, Lesgold, Eggan, & Gordin, 1993)

22. Distribution of knowledge through documents, drawings, video, and user service (Steve Kennedy (personal interview, July, 6, 1994))

23. Reusable software frames or modules (Kennedy, 1994)

24. Reduced development time (Kennedy, 1994)

Object technology together with expert systems may accommodate features and capability to change enterprises. They are said to constitute a forward looking process of revolutionizing software development. The software and hardware tools have developed so that the computer is merging with human knowledge. These tools may help create a major shift in the computer paradigm to develop knowledge management systems that are event driven (Servio, 1993; Taylor, 1993, pp. 84-107; Tan & Goh, 1999).

Limitations and Delimitations

In 1989, Paul Siegel wrote that computer methods have shown progress toward elimination of problems (those of cost, time, and usability) and may be considered subtle, flexible, and efficient for application (Siegel, 1989). This still remains to be demonstrated. Software manufacturers such as Emerald Intelligence® and other proponents of computer based expert systems believe that these systems have advantages when they are compared to conventional systems (see previous list under traits). Since this study can evaluate only a limited number of potentialities, previously listed traits are to be addressed as part of the software, the knowledge base or the job-aid development. While this study may contribute to the demonstration of traits it cannot directly address all issues in depth. If the software or the knowledge base does not include a characteristic, the development may not compensate for its absence. This study intends only to: demonstrate the use of these traits through training development, using expert-object software, and direct that toward training professionals.

Prior formal understanding of Instructional Systems Design (ISD) and Criterion-Referenced Performance-Based Instruction may be necessary for reader understanding of methodology used in this research. This research can neither attain instruction toward a thorough understanding of these topics (ISD) nor is it intended to.

The software for development is an 1995 version of Emerald© -- Procedural Advisor™. This environment is for knowledge development. It includes tools for industrial information presentation, and a service-exchange. This version of Procedural Advisor™ cannot not draw inferences from ambiguous conditions or situations. Consequently, it depends on crisp known conditions. Only when using Boolean search or mathematical processes, can this version of the product give judgments on probabilistic percentages. Otherwise, the product follows known paths. This limitation directs problem resolution to situations with previous or existing knowledge. Consequently, this development is a knowledge-based expert system that uses object technology to build interactive computerized knowledge-based systems.

The product is available for both the Macintosh® and IBM® hardware platforms and later versions may correct for limitations. The minimal system for practical application and operation is a personal computer with a Pentium 100 MHz. processor with eighteen or more megabytes of memory and windows 3.1 operating system. Subsequent upgrades to the program demand more capability but the above system was found to be satisfactory for the earlier version.

The training document by C. P. Campbell, of the University of Tennessee, Human Resource Development, Determining the cost effectiveness of training (Appendix A), is the expert source material for the knowledge base. Accordingly, knowledge development is not part of this study.

This study does not attempt to evaluate knowledge management, nor intelligent systems as such. For explanatory purposes, the five phases of intelligent systems are addressed along with the perceived intelligence of both expert systems and object technology. This study does not address the issue of intelligence in computer systems.

Definitions

Unusual word combinations and terms used in this study are defined below. These definitions reflect the perspective found in literature on this subject.

Artificial Intelligence -- the use of computer technology to mimic human thought process and reasoning, through which computers appear to learn.

Computer Aided Instruction (CAI) -- instruction that uses a computer to enhance or to implement instructional content separate from human intervention.

Expert System -- a computer based software system that uses knowledge, facts, and reasoning techniques to solve "problems that often require the abilities and experience base of an organization's best person" (Oxman, 1989, p. 1). An expert system can be a job-aid.

Expert-Object -- software that combines object technology and expert systems in a single development shell.

Heuristic -- knowledge gained over time through experience and discovery.

Inference Engine -- the logical processing system used to achieve solutions through mathematical comparison.

Job-Aid -- those visual and textual instruments that are referenced to expedite understanding. With time, individual use of such devices is intended to diminish from frequent too occasional. In this study the traditional self-contained instructional module, in hard-copy form, is considered a job-aid.

Knowledge-Based Systems -- the same as expert systems but may not contain an inference engine.

Knowledge Engineering -- the application of knowledge, knowledge representation, design, and programming, for task or work breakdown and analysis -- deals with heuristics to organize information with appropriate action.

Method -- "A procedure contained within an object that is made available to other objects for the purpose of requesting services of that object. Most (in some languages, all) communication between objects takes place through methods" (Taylor, 1993, p. 135).

Object Technology -- software that contains related procedures, methods, and data in package or modular form (Taylor, 1993, p. 16). These are building blocks that repeatedly frame real world objects through image recognition(Booch, 1994).

Procedure -- "A sequence of instructions to a computer indicating how a particular task should be carried out" (Taylor, 1993, p. 139).

Chapter II

Review of Literature

The review of literature was conducted to achieve an extended understanding of the extent and progress of knowledge-based expert systems using object technology in the computer paradigm. An extensive search was made of available articles and books. In addition personal interviews were conducted with subject matter experts, and seminars were attended on related topics. National data bases and private sources were searched: Office of Scientific and Technical Information (OSTI), National Technical Information Service (NTIS), Oak Ridge National Laboratory (ORNL), Educational Research Information Center (ERIC), CD-ROM business systems, and private research from industrial applications. The review of literature is broken down into the following topics

1. Object Technology
2. Expert Systems
3. Instructional Systems
4. Industrial Systems
5. Recent Developments
6. Summary

These topics contain elaborations about the effectiveness of expert-based instruction, and object technology to training.

Parallel disciplines contain methods for augmentation of human thought, and reasoning. They use computer-based methods and features.

The knowledge-based expert-systems instruction has shown promise for effectiveness in training (Lajoie, & Lesgold, 1992). Previously, effectiveness was limited by the time of development (labor intensiveness), cost of production, and cost of software. Without custom modification, the resulting products were not reusable (Servio Corp., 1993; Krovvidy, 1999). Costs, along with other associated problems, tended to preclude the use of expert systems. Robert Uhrig of the University of Tennessee; Department of Nuclear Engineering said that application of this technology has not achieved the use expected (Uhrig, 1994).

Similar domains were found in: object technology (Taylor, 1993), knowledge engineering (Oxman, 1989), technical training (Department of the Air Force, 1993), adult education (Boone, 1985), systems theory (Senge, 1990) and expert systems (Booch, 1994; Oxman, 1989). Each discipline talked about the domain differently; but performed similar operations in very nearly the same way. For example, technical education supported the experienced practitioner of a craft as the expert. That person with authority who could best perform a task and could speak about task performance within a system (Department of the Air Force, 1993). From the expert's knowledge, jobs and tasks were separated for later program development (Campbell, 1986; Mager & Beach, 1972).

Oxman stated that knowledge engineering supported and used the individual with extensive heuristic knowledge as the expert. Further, he suggested that tasks be broken down into smaller subsets, a process called work-breakdown analysis (Oxman, 1989) or task analysis. Boone's principles especially those of programming, have been an essential part of knowledge engineering, of adult learning, and of object technology. Boone wrote about a map, program planning, and a conceptual framework; that involved decision making, change, culture, and needs (Boone, 1985). The structural philosophy of object-based expert-systems (Booch, 1994; Taylor, 1993), has been essentially system theory as supported by Peter Senge and alluded to by Edgar Boone (Boone, 1985; Senge, 1990). Technical training has advocated cyclical interactive models (Department of the Air Force, 1993). These models have supported complex structures; have provided for inheritance and have very much used decision making expertise (Taylor, 1993). Consequently, a very near similarity has existed in the philosophy and methods of object technology, expert knowledge systems, and training development, in particular; while not excluding associated similarities with knowledge engineering, adult education, and systems theory.

In a study of an apprenticeship model, scientists Lajoie & Lesgold derived training principles for the United States Air Force. These points were not different from those advocated by technical trainers and vocational education. After rewording these principles will be considered training principles

1. Teach knowledge and skills together
2. Embed learning in the application environment
3. Provide learning through practice and observation
4. Emphasize learning through experience by doing
5. Provide continuous support throughout the process
6. Train specifics not abstractions
7. Include the most difficult tasks with explanations, work place vocabulary, and help
8. Model the real expert
9. Emphasize goal development, main theme to sub-goals
10. Provide adaptable structure to allow individual learning differences (Lajoie & Lesgold, 1992)

Object Technology

Philosophy and science contributed to the advancement of the object model. The Greeks innovated the idea of the world viewed either as objects or processes. Descartes, in the 17th century observed that humans apply objects naturally to the real world. In this century, Rand's philosophy of objectivist epistemology expanded on the theme (Booch, 1994, p. 34).

Mark Ortung, a manager with Arthur Anderson Consulting, said, "the Object-Oriented-Enterprise makes multimedia technologies natural and easy" (Headberg, 1993, pp. 119-128). Through object technology, computer-based program development, specifically expert systems, may have time-saving and economical tools to create credible computer-based instruction. Expert systems and object-oriented representations provide cohesion to bind systems together (Headberg, 1994).

Within the last 10 years, object technology has been slowly gaining usage. Object technology moved from the laboratory in 1987 and was introduced to the public. Today, many software vendors use object technologies. This new software is powerful and inexpensive (Servio Corp., 1993).

Object-oriented programming technology has not been simply another kind of programming language. It has been a forward-looking process of revolutionizing software development (Taylor, 1993).

Object programming parallels the changes that took place in manufacturing when Eli Whitney developed interchangeable parts for manufacturing. Because of interchangeable parts, instead of unique parts produced one at a time by individual craftsmen, skilled people could use standard parts to produce identically functioning mechanisms (Taylor, 1993). Object-code programming provides today's software with the capability of interchangeable parts. Previously, highly skilled programmers individually created each unique part. The parts were usually not reusable and would not fit other software. With object technology, interchangeable software parts are available. Consequently, object technology may be both cost effective, ready, and powerful enough to change enterprises as a whole, including education (Taylor, 1993).

Object technology provided the following to computer applications

1. Faster development
2. Higher quality
3. Easier maintenance
4. Reduced cost
5. Increased scalability
6. Increased adaptability

While object technology has had promise, it has lacked maturity, standards, better tools, faster execution, qualified people, economy of conversion from past technology, and support for large-scale modularity (Taylor, 1993). However, these limitations may no longer be true.

Expert Systems

Certain industries used expert systems to reduce costs and to increase production (Steve Oxman, (personal interview, July 29, 1994). Training programs used expert systems to model the subject or the procedural authority. As such, the expert system has been an excellent tool for learning (Siegel, 1989). According to U. S. Army Major Orlando Illi, chief of the Knowledge Engineering Group, Military Studies of Expert Systems reported improved effectiveness of his technical staff by enhanced training, improved diagnostics, improved bottom-line cost, and decreased training time (Kay Keppler, 1993).

Development methodologies for expert systems differed from conventional systems. Expert systems have become

1. Interactive
2. Exploratory
3. Rapid to prototype
4. Capable of generation self-documentation

Conventional systems were linear. They also required specific analysis, and customized systems. Documentation could not be generated by the system. Consequently documentation was largely hand written or typed. The speed and effectiveness of development, as well as analysis, were the key points of expert system computer methodology (Oxman, 1989).

Expert systems had additional attributes, not all of which were always present. Expert systems have typically

1. Pursued goals that vary over time

2. Incorporated, used, and maintained knowledge

3. Exploited diverse, ad hoc subsystems embodying a variety of selected methods

4. Interacted intelligently with users and other systems

5. Allocated their own resources and attention by providing intelligent storage, indexing, retrieval, and distribution (Erman, Lark, & Hayes-Roth, 1988)

6. Provided features to show lists of information obtained in searches through the system

7. Included a tracing function that showed current information about the problem-solving process (Milheim, 1990)

In the purest sense expert systems include an inference engine that allows the acceptance of information as independent facts or rules. The rules allow handling of

1. Uncertainty

2. Contradicting, and conflicting information

3. System choice for decision path and segregation of small pieces of information (Milheim, 1990)

In turn, inference allows inclusion of certainty factors for users to inquire about why the system asked a question. The user is then provided an indication of the confidence level of the outcome (Milheim, 1990, pp. 5-8).

Digital Equipment Corporation successfully implemented an expert system before 1980, called XCON (McDermott, 1982). Many research efforts followed in various areas of artificial intelligence. Widespread use of expert systems was beginning by 1995. Today implementation strategies are detected in literature (see Recent Developments later in this section).

Instructional Systems

Previously, these systems were referred to as intelligent instructional systems. They were difficult to research and to implement. Instructional systems may have hope in object technology to reverse difficulty (Farr & Psotka, 1992).

Literature has shown a relationship between instructional research and practices of several seemingly separate disciplines. These disciplines tend to operate autonomously without reference to or awareness of each other. Three of these disciplines are knowledge engineering, cognitive scientific study, and training development. Each of these is in fact researching and working with instructional knowledge development.

Knowledge engineering and computer applications have been an integral part of a paradigm shift for instruction. Knowledge engineers merged the computer with the individual expert, through structured interviews with experts to extract information and to structure it for permanent input into computer based systems -- specifically expert systems (Oxman, 1989). These methods were similar to those used by training professionals when they performed job analysis.

Cognitive scientists have concluded that augmentation of the human thought and reasoning process naturally should include learning. Almost without consideration, one knows that the elements of a learning situation contain the most direct implementations of human reasoning (Farr & Psotka, 1992).

Technical domains tended to be more definable than other domains such as cognitive, artistic, or engineering. Because of these traits, intelligent instructional systems have concentrated on the technical (Farr & Psotka, 1992). Therefore, efforts of many disciplines have merged to form commonly used sets of methods such as needs assessment, job and task analysis, systems analysis and program planning.

Because of new development tools, expert system development along with object-code-technology development, may contribute greatly to the evolution of instructional systems. Admittedly, for expert systems to be usable they had to become object oriented. In 1970 implementing a Linguistic Instruction Sequential Program (LISP) development could take 5,000 hours. In 1985 a better LISP-based development tool could require only one hour to do the same task. Today, the same development can take ten minutes or less -- using non-LISP expert tools (Oxman, 1989).

If anything in literature seemed compelling, it is that science accepted the emerging intelligent computer-based instruction as fertile ground for research. Booch wrote that, "Philosophy and science have contributed to the advancement of the object model" (Booch, 1994, p. 37). Researchers pursued problems to improve understanding of human processes. Activity often involved the construction of intelligent systems that mimicked certain aspects of human behavior. Erman, Lark, and Hayes-Roth, 1988, pointed out that intelligent systems differed from conventional systems.

A study conducted for the Air Force by cognitive scientists, developed SHERLOCK, a computer-coached practice environment. Technicians who spent 12 days tutoring on SHERLOCK (a total of 20 to 24 hours) were able to troubleshoot failures as well as persons with 4 years of on-the-job experience. Those who went through normal apprenticeship training showed only emerging or entry-level competence (Lajoie & Lesgold, 1992).

The researchers used a pretest-posttest control group design. They elected to use a large convenience sample. Matched groups from the entire population of students for a training time-period. Structured interviews allowed assessment of the differences between the experimental and control groups, through presentation of pretest-posttest problems. Since the article did not differentiate, prior testing by the Air Force was assumed for selection of the two groups. To evaluate progress, structured interviews were conducted. Questions based on actual failures were different from similar tutor problems used by SHERLOCK (Lajoie & Lesgold, 1992).

Chi-square distributions established correlation between groups. At pre-testing the groups matched. At post-testing the experimental group mean equaled 30 and the control group mean equaled 21. The experimental group solved significantly more problems than the control group. This time there was a difference. The experimental group showed more ability and fewer moves to achieve solutions. The method for determining experience level was not mentioned (Lajoie & Lesgold, 1992).

Conclusions emphasized nine points. In general, these matched vocational and technical training principles. In abbreviated form these were

1. Teach knowledge and skills together
2. Embed learning in the application environment
3. Provide learning through practice and observation
4. Emphasize learning through experience by doing and provide continuous support throughout the process
5. Train specifics not abstractions
6. Include the most difficult tasks with explanations, work place vocabulary and help
7. Model the real expert
8. Emphasize goal development, main theme to sub-goals
9. Provide adaptable structure to allow individual learning differences (Lajoie & Lesgold, 1992)

A review of literature revealed many descriptive research efforts but few experimental designs. Lajoie and Lesgold are exemplar to experimental designers; issues were clearly presented, and the plan to result was smooth.

Development of SHERLOCK II followed SHERLOCK I. One of the major variations used in the new model was the precise use of imprecise numbers called "fuzzy set theory" or "fuzzy-logic". The use of fuzzy-logic constituted a major departure in technology and methodology. Fuzzy logic allows precise handling of ambiguity. This methodology is also a trait of spoken language.

The SHERLOCK II computer-coached practice environment trained electronic technicians to diagnose faults in a complex electronic testing system used to check other systems for faults. A knowledge base was employed for student modeling. It was a realistic simulation of a real setting. The basic idea of the scheme was to give students control over their learning and help them develop metacognitive skills while providing information to solution, if information was desired.

The SHERLOCK II system employed object features such as: intelligent graphics interface; objects in the learning environment, "tools", that permitted student incorporated methods; and a replay feature. The replay feature, reflective follow-up (RFU), transferred some of the load to prevent information overload. The RFU included path tracing; system comments on solutions; solution replay; solution comparison to system ideal; proper system behavior versus problematic system behavior; and student contribution to choice of problems. The intelligent modeling environment was a graphical object called the student trace made up of component objects.

> The 'intelligence' in object oriented systems like SHERLOCK II was encapsulated in computational 'objects'. The study defined an object as an independent piece of computer programs that store its own local data and can thus respond to various requests that other parts of the system might make of it. (Katz, Lesgold, Eggan, & Gordin, 1993, pp. 99-117).

The purpose of the SHERLOCK II development was to minimize programming complexity through by imprecise student modeling with fuzzy set theory and to minimize the knowledge engineering effort required to develop the student knowledge-base. Additionally, a third purpose was employed, that being object technology and the implied intelligence such methods add to software. Unfortunately, the adequacy of this development was not evaluated and was relegated to a later publication. Literature search did not show follow up publications.

The examples discussed thus far fall into a category in literature called intelligent tutors. The developments discussed thus far have each used knowledge-bases, employed expert techniques and one, SHERLOCK II, used object methods. The next study revealed a set of traits for so called intelligent tutors that involved groups of synonymous terms from which this writer selected descriptive titles for headings as seen in table 1. These were: model-tracing, model states, or knowledge states; instructional methods or instructional approach; and resulting skill or resulting knowledge. These additional attributes are three sets of five parallel but sequential phases: These phases or levels of competence were described as major techniques in the design of computer systems for research in human learning (Fink & Herren, 1991).

These systems went beyond Computer-Aided Instruction (CAI) to systems adaptive to student response. They maintained a model of the expertise being trained; of the student being trained; and of the student instructional strategy employed including trials, comments, and remediation. In addition, alternate solution paths were provided with a method for retracing the path both forwards and backward. The development of systems for tasks called cognitive tasks included diagnostics.

Table 1. Modeling the student

Knowledge States	**Instructional Approach Phases**	**Resulting Knowledge/Skill**
No Knowledge	Static Overview	Declarative Knowledge
Limited Knowledge	General Procedure-Oriented Knowledge	Procedural Knowledge
UN-automated Knowledge	Guided-Example Exercises	Procedural Knowledge/Skill
Partially Automated Knowledge	Unguided-example Exercises	Procedural Skill
Fully Developed Knowledge	Automated-Example Exercises	Automated Skill (habitual)

Intelligent computer instruction as three sets of five parallel phases through which instruction must progress -- the three categories emboldened above. The ultimate development of knowledge is (**habitual**) fully automated skill where the primary task is performed with a secondary task and the secondary task occupies the majority of attention.

Note. The information in column 1 is from "Modeling the student in SHERLOCK II" by Katz, S., Lesgold, A., Eggan, G., & Gordin, M., 1994, In J. E. Greer & G. I. McCalla (Eds.), Computer and systems sciences: Vol. 125. Student modeling: The key to individualized knowledge-based instruction. p. 111. (1st. ed., pp. 99-125). Berlin: Springer-Verlag.

Note. The information in columns 2 and 3 are from "An intelligent tutoring system for the investigation of high performance skill acquisition," by Fink, P. K. & Herren, L. T., Regian, J. W., 1991, p. 8. (NAS 1.26:188827). Texas: University of Houston - Clear Lake, Research Institute for Computing and Information Systems.

In the development study of Console Operations Tutor, discussed as an intelligent system, Fink & Herren examined a particular class of high performance skill. They wanted to examine system effectiveness for lower cost, shorter time-to-train, and longer retention of the skill. Ultimately the study did not examine these traits. I provided instead a fully developed tutor to psychologist for their continued evaluation. The system had four parts: interface, parallel student and expert model, and instructional module. The instructional model for an effective system constituted implementation of an expert-system domain. The domain expertise implemented in the expert model, in turn, constituted implementation of a specialized knowledge-based system that contained the knowledge and problem solving skills to be taught. An effective system to them was the equivalent of several different but parallel knowledge-bases. These in turn added to the instructional model and the software design.

Fink and Herren addressed the phases of training through which students using such a system must progress (see table 1). The design they used for instructional content was the classic tree structure. Their goal was to develop a replicable, fully automated approach to training high-performance tasks. They wanted to see if tasks trained in such a way transferred to operational environments. Further, they wanted to validate or refute that automated task performance was more reliable, less susceptible to stress, and less susceptible to skill degradation than non-automated tasks (the last item as seen in table 1). Tasks conducted under stress using unguided procedural skill while performing a secondary task that occupied attention, were automated tasks (Fink & Herren, 1991).

No evaluation of goals occurred. They did achieve a tutor. It was delivered to psychologists for further study. However, literature has not shown follow up to this development.

Another knowledge-base development effort, produced for the United States Air Force called GUILD, resulted in a development tool for training. The study reported observations about computer training and defined direction to a commercial product. First, the study noted a lack of spectacular impact of computer instruction. The reasons were recorded as a combination of education, human psychology, and computer technology. Many developments were said to equaled page turning devices that replicated the original-text book material and used none of the computational tools. Additionally, most systems were pre-programmed and used inflexible methods to meet the psychological requirements of students. Second, the study noted the emergence of expert systems that can provide promising tools for capturing human thought, thus modeling of both the student and the expert become possible. Such new systems were to be more adaptive through flow charting or cubical structure. Programming and progress was to be non-linear. New systems were to adapt to individual strengths. Patterning of presentation and learning decisions were to allow choice of subject, difficulty, skill level, and path. Consequently, new systems could reduce learning time, enhance learning levels, and motivate students. Last, GUILD was capable of becoming such a tool.

After two years of development and significant progress on software, developers decided to turn the project efforts to commercializing GUILD. Windows became a de-facto standard in 1991, a tremendous opportunity presented itself and those efforts were pursued (Frogner, 1992).

The PASCAL "Bridge" was developed to assist novice programmers in design and testing of Pascal computer code. The tutor prompted conceptualization of programming through intermediate solutions. A study was conducted with 260 subjects who spent 30 hours each learning from the Pascal Bridge. Learning efficiency was derived from the time subjects took to complete the tutorial. Subjects could not continue to a new problem until they were completely successful in the current one. Three criterion posttests were administered to estimate learning outcome. They measured retention, application, and generalization of programming skills.

The tutorial was equal to half a semester of introductory Pascal. The estimated time, necessary to advance through the material the conventional way, was to be 35 hours. The study measured that time spent learning a half-semester of Pascal on the tutor took less time (mean = 12 hours, SD = 5 hours, normal distribution). On average Pascal took three times as long to learn in a conventional classroom setting (Shute & Psotka, 1994).

A learning study conducted using "Stat Lady" tutored probability on traditional lecture and no-treatment on the control group; showed both treatment groups learned significantly more than the control group. The treatment groups showed no difference between pretest and posttest. The lecture control group prevailed on procedural skill while the treatment groups achieved more declarative knowledge. Continued study revealed an interaction in aptitude-treatment that indicated no difference between low-aptitude subjects in learning outcome by condition. High-aptitude subjects showed significantly more learning from "Stat Lady." The suggestion in these studies was that learning maximized when a teacher-computer interaction occurred with students (Shute & Psotka, 1994).

The majority of studies involving expert systems have been qualitative or descriptive. While these studies have added to the knowledge and have helped narrow the computer instructional model, they may not have been entirely pragmatic. Pat Kyllonen emphasized that expert systems have been embedded in over 100 commercial software packages; for example spell-checkers and thesaurus in word processors. Kyllonen said that expert systems have been the type model for artificial intelligence systems (Shute & Psotka, 1994). Branching has been a fundamental aspect of intelligent (expert) systems. Branching allowed techniques to empower the intelligence by going beyond the planned path to understanding inputs and generating outputs somewhat autonomously. Branching was a break from older methods.

Shute & Psotka recorded specifications of intelligent instruction that have not changed since 1973 when Hartley and Sleeman argued that such systems must possess

1. Knowledge of the expert model (domain)
2. Knowledge of the student
3. Knowledge of the teaching (tutor) strategies

While these have not changed, evidence has shown that they have been added to and expanded (Shute & Psotka, 1994).

Industrial Systems

An interview with Steve Kennedy, a knowledge engineer and administrator with Emerald, indicated a perspective similar to that shown in the literature search of learning systems. Emerald believed we are entering an era of service delivery and distribution of knowledge. Steve said, "One distributes knowledge through documentation, drawings, video, customer field services, and training." Since their product developed as an industrial tool, service may include: machine setup, process configuration, machine operation, maintenance, repair, trouble shooting, scheduling, material moves, stock tracking, inventory moves, parts on hand, and supervisory services. The problem has been that companies developed knowledge and the knowledge either deteriorated with time or left the company. A different problem has been knowledge transfer. Perhaps knowledge passed to a distributor and from the distributor to the end user. From the original equipment manufacturing company, to distributor, and then to end user, the level of expertise, eventually, was much lower than the previous step. Figure 1 shows Emerald© Intelligence's view of a knowledge-transfer-cycle. Note that knowledge transfer may never have reached the original peak (Steve Kennedy,

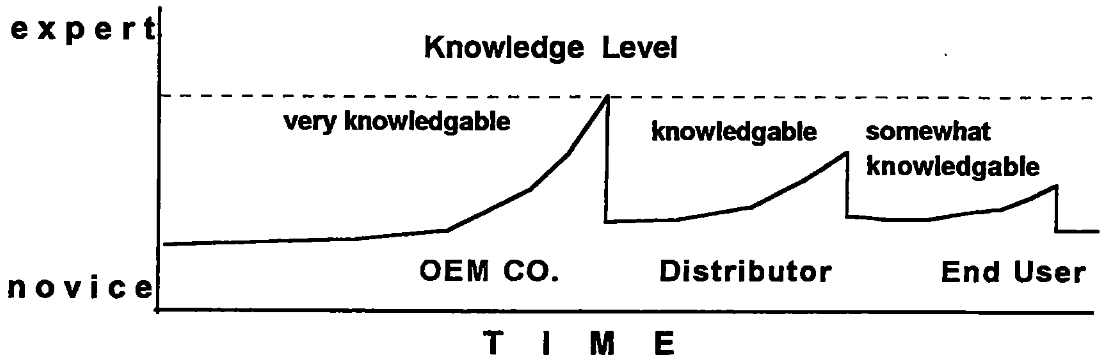


Figure 1. Industrial knowledge transfer and degradation

Note: From "Interview on Emerald Intelligence®: Empower™", Steve Kennedy (personal interview, July, 6, 1994), Ann Arbor, Michigan.

(personal interview, July, 6, 1994)).

Industry has been specifically interested with quality. Presently, industrial knowledge has been recreated continually in some processes while it was lost in others. Provision of real time information to all levels of industry is important for the advancement of process quality. In figure 2 information is shown as knowledge available to the end user. As such end user was shown to achieve some higher level of expertise toward quality advancement, rather than some level of mediocrity. The overall scheme was to integrate software technologies and services, designed to capture and enhance information and expertise; with which

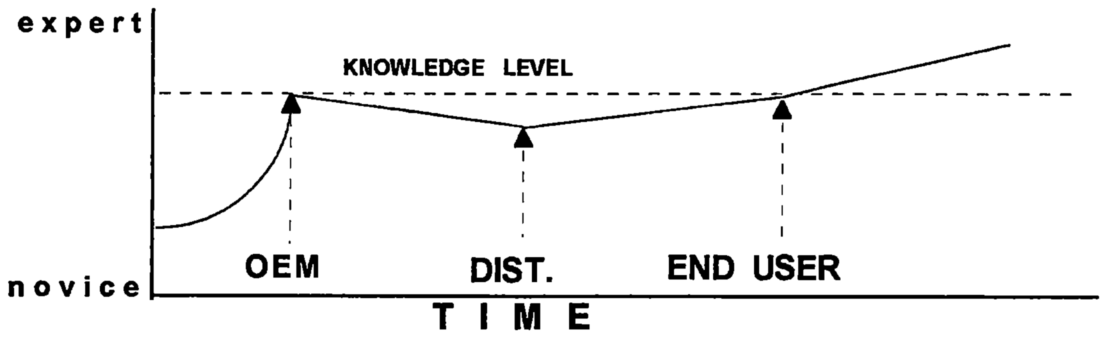


Figure 2. Non-deteriorating knowledge base-line

one could enhance the support of equipment and processes. These were the advantages of Procedural Advisor™ as a set of products.

Procedural Advisor™ developers allowed branching as a programming method. Object icons provided the programmer methods for use -- a fill in the form approach. The programming process resulted in click to fill in and drag to place, icon objects, for the majority of the process.

Steve Oxman of OXKO® in a personal interview, reported increasing industrial success with expert systems, especially object systems. At the time of the interview OXKO® was at 98 successful industrial applications. One of the earlier systems reported and nationally advertised, was built for a Texas Nylon company. There the process expert produced Nylon 11% more efficiently while he was in the process control position. OXKO® modeled his expertise with the process using Level 5® expert development shell. As a result, the control operators produced Nylon 11% more efficiently all the time. Nylon production was almost flat between industries. Methods and process were thought to be mature and few gains were thought possible. OXKO's development forced the Nylon industry to gear up to expert systems (Steve Oxman, (personal interview, July 29, 1994)).

Oxman reported a more recent development where the expertise of steel operators with 30 years of experience on a process, was modeled. New operators took years to train. The operation was highly skilled and highly intuitive. Only experienced operators of thirty years operated and produced that product. When running the completed system, during testing, an operator turned to OXKO's knowledge engineering representative and retorted, "If that system is so good, let's see you produce a batch of ... steel." The OXKO® employee asked only if he could use the system. He then produced three consecutive batches of steel, perfectly. The operator's pallor changed. He realized the system could augment a novice to produce the same product he could produce, as an expert with thirty years of experience. While only time will tell the impact of such systems on jobs, in this instance, experienced workers used the system to ship products with less turnaround time, more accuracy, and more efficiency. The result was reduced cost with increased customer satisfaction (Steve Oxman, (personal interview, July 29, 1994)).

Figure 3 is a rendition of Emerald not OXKO® but it shows the industrial experience. The implication is that experts may not use the extensive procedural content of an expert system, the system may frustrate him, but the novice may be extremely dependent on the procedural content.

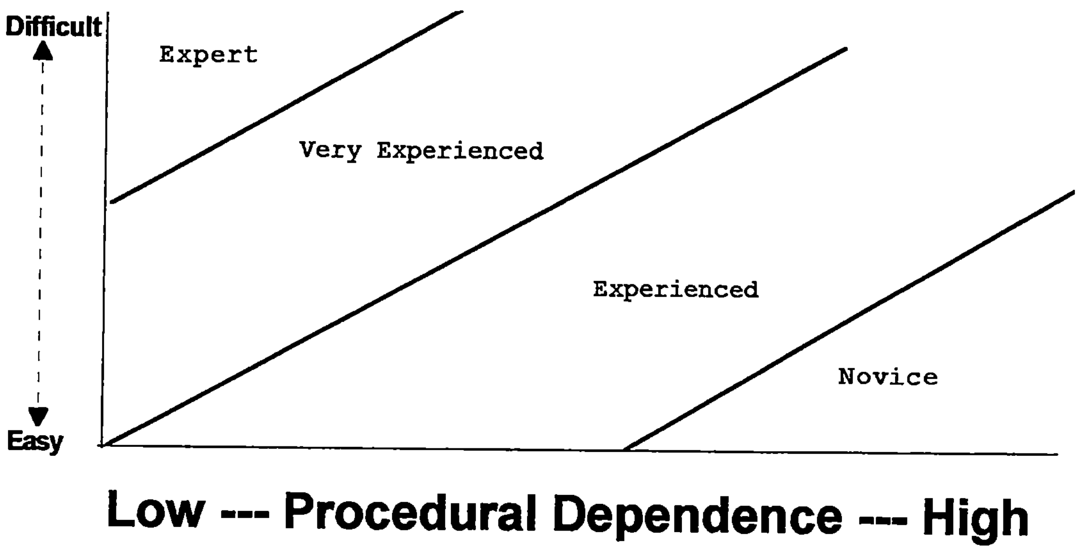


Figure 3. Relationship of knowledge to procedural dependence -- as experienced by Emerald Intelligence®.

Note: From "Interview on Emerald Intelligence®: Empower™", Steve Kennedy (personal interview, July, 6, 1994), Ann Arbor, Michigan.

Naturally, this depends on the level of expert knowledge and the level of the novice.

OXKO® reported, in Knowledge transfer at work: Success stories from the OXKO® corporation, a "knowledge paradox". The knowledge paradox was a belief that developmental knowledge often has not reach the decision makers. OXKO's experience included mixing and melting operations, printing, training, furnace operation, lot selection, maintenance systems, product quality, management systems, and others (The OXKO® Corporation, 1994, pp. 1-18).

In an assistant or tutor produced by OXKO®, MIL-STD-2036 incorporated the written equipment specifications of several government standards and developed new specifications for electronic equipment. Due to changes in standards, experienced developers needed to be re-trained for the new standard. Most retraining occurred on the job. The process of using existing specifications no longer worked. The new requirement insisted on minimized cost, and reduced time to create specifications. OXKO® designed an expert advisor -- job-aid -- and tutor for application to rapid development of electronic equipment specifications. The system contained a generic template specification to aid the developer based on developmental inputs and answers to specific questions regarding the equipment. Additionally, a hypertext version of the full standard linked the system for immediate help. Video segments incorporated an aid to the users' understanding. The net result was a faster specification development process coupled with an ability to be productive during the learning process of assimilating new specification knowledge. Presently, experienced specification developers can leverage experience by allowing the system to create the basic template. Then the human expert can use the template to create finished specifications in much less time than was previously required (The OXKO® Corporation, 1994). This example raised the question, of knowledge acquisition with active computer display, if it is possible, is formal training really necessary? While the study implies the answer, further research is needed to investigate the issue.

Recent Developments

By 1999 the Occupational Safety and Health Administration (OSHA) developed no less than 11 unofficial test versions of expert system advisors. The topics covered ranged from calculating the average company cost (expense) of an accident, to advising loggers on the technicalities of accidents in that industry. These are called advisors because they replace an expert in the dissemination of information (Expert Advisors -- http:\\www.osha.gov).

Generally the emphasis was toward expert system or knowledge system shell implementation techniques and methodology. These tended away from the high level artificial intelligence programming languages like LISP and Prolog™ or others. In essence expert systems shells can be coded using object methods either with procedural techniques, logical rules, or a hierarchical linguistic reduction. With the procedural approach, the programmer established the order of events then the program sequentially modeled the developed events. The procedural approach originally used traditional programming languages. These were dependent on sequence and syntax. Flow chart knowledge-development shells and rule-based development shells have been originated using these methods. With a rule-based approach, events were declared and maintained without reference to how until the rule was evoked. Then the rule was compared mathematically in a computer inference engine. Some of these used truth tables and others used if-then-when logic. Often these rule-based systems were called expert-development shells. The linguistic method compared to both the rule approach and procedural approach, except word matching occurred from global to specific. This method used verification and conciseness until the system mirrored the query. At that point the rules were fired based on verification of the verbal input. Each approach has tended toward object methods and away from older high level implementation languages. Whereas the linguistic approach may retain autonomy the other two have developed similarly. One was called a knowledge-development shell and the other was called an expert-development shell. Examples have been found of simplified flow chart methods used both for knowledge developments, and expert rule developments (Kronfeld & Tribble, 1995; Hicks, 1999).

Knowledge base management techniques have traditionally been part of the knowledge engineering function but tools are emerging which allow development of the system along with the knowledge. A properly designed system can reduce the time necessary to develop an expert system. Such system tests the input of both query and user response during development (Hicks, 1999).

Summary of Review of Literature

Literature shows an opportunity to improve the computer model and reinforce training. Through expert referenced systems; computer job-aids and computer instruction may become effective for training. Effectiveness must include reduction of cost and reduction in time of development. Object technology is critical to achieving effective systems.

It should be no surprise that objects can allow reduction in limitations, and in development time of computer software. Objects are a representation of the real world in interchangeable and reusable software modules. Philosophy has upheld the association of real world functions to object representation. As such, it is reasonable to think that computers which better model human thought and reasoning will use complex real world information. This is a major change in the computer paradigm.

Knowledge engineering, training analysis and expert systems development share mutual processes and methods. They both integrate human knowledge through intelligent systems. Interrelationships carry over to technical training, adult education, and systems theory. In general there are many shared traits.

Scientists embraced learning through computer based instruction. Industry used expert systems to reduce cost, increase production, or increased customer satisfaction. The systems provided tools to persons that were job-aids for improving individual performance. Training programs used expert systems to model the subject or the procedural authority. Persons using these tools, in government agencies, combined standards from several other agencies to generate completed equipment specifications, with reduced time and complexity. The U. S. Military reported studies of expert systems for improved effectiveness of technical staff. Frequently, developmental intelligent computer instructional systems often used expert systems.

Systems development has been difficult with custom built non-reusable computer code. With time, systems are becoming more than another kind of programming language. They are becoming a forward looking process of revolutionizing software development -- paralleling the development of interchangeable parts for manufacturing.

Branching was a break from time tested specifications of intelligent systems; branching allowed exploration beyond a planned path. Emerald Intelligence® included branching in Procedural Advisor™.

Emerald believed that service delivery of knowledge was the important item their system brought to training and to industry. The company believed knowledge to be distributed through, documents, drawings, video, and customer services. This worked together through integration of knowledge-bases to prevent a deterioration of knowledge, the desired result, and provide an increase of knowledge to system users.

Branching in intelligent systems has been a fundamental aspect of expert systems. Expert system development was different from conventional linear systems. Expert systems were non-linear and were reported to be faster to develop; thus improving the object model.

Object technology added additional intelligent elements called graphical objects. While none of these things were really intelligent they did seem to act intelligently. Such objects maintained contact between the computer program and the user. The result was augmentation of human thought and reason through computer generated objects.

Recent developments place emphasis on development techniques. These object-based methods were either procedural, rule-based, or linguistic. These followed the nonlinear trend attributed to expert systems. The tendency has been toward higher level and flow chart methods and away from rigid sequences.

Object models and expert systems have had strong interrelationships. By these tools, knowledge engineering has developed to the direct merging of the computer with human knowledge.

Chapter III

Methodology

The chapter presents the objectives of the study and describes the methods for attaining each. The objectives were to

1. Develop a computer job-aid for instruction of industrial trainers, using an object-based expert system

2. Pilot-test operation of the computer job-aid

3. Compare the developed computer job-aid with the standard paper-based (hard copy) job-aid for (a.) content understanding and use, (b.) completion time, and (c.) participant satisfaction

These objectives were set forth because advanced active computer systems were thought to enable training transfer, increase potential, and reduce limitations, and like paper job-aids reduce the need for formal training. Similar methodological characteristics were found between training and instruction, computer knowledge development, knowledge engineering, psychological research on learning, and these computer application technologies.

Job-aid Plan

To satisfy objective one: the development of a computer job-aid for instruction of industrial trainers, a commercially available product was chosen. The object-based expert shell was Emerald Empower™ Procedural Advisor™. This system included the capability for tree structure programming, and representation of subject matter that included graphics, knowledge-base procedures, text, and desired performance (behavior).

Since computer knowledge system implementation required preexistence of expert knowledge, the resource exhibited in Appendix A, Determining the cost effectiveness of training, was chosen. It was an existing printed training module by C. P. Campbell of The University of Tennessee, Department of Human Resource Development (Campbell, 1994). It contained expert instruction methods and knowledge that was useful to industrial trainers.

Development system shell. According to objective 1, on the known problem of analysis of training cost effectiveness, research proceeded to resolve problem situations in the development of a computer job-aid for instruction of industrial trainers. Procedural Advisor™ was judged to have tools to allow development of previously existing knowledge in a way that allowed advantageous problem resolution to training.

Within Procedural Advisor™, knowledge distribution occurred through representation of the knowledge domain (knowledge of the expert) in the knowledge environment (the software), was applied by the run-time-environment (the computer), and was structured in the advisory system using the tree structure (programming). Within the advisory system were consultation windows (forms), guides to help users through the content (how-to procedures), and a display window. An assortment of media applications was available to the run-time-environment. The system had place holders (path retracing features) available with only one click of the mouse. The tree structure was invisible to the end user but it was available to the builder. The Emerald© user's manual on using objects and methods showed the software features listed below

1. Windows, menus and dialogs
2. Trees
    a. Branching
    b. Dead end branch
    c. Quick jump
    d. Branch from other trees
3. Objects
4. Object-edit icons
5. Symptoms
6. Solutions
7. Test mode

8. Information and actions

9. Information files

10. Hot spots

11. Methods

12. References

13. Expressions

14. Dynamic data exchange and linking

Research indicated that the time requirements for application development, and system capabilities were problematic in building the computerized knowledge-base. Servio Corporation indicated a decline from the thousands of hours necessary to write original code (Servio Corp., 1993). For development time to be reduced further, computer tools had to resolve quickly the problem situation on known processes, modify those problems through resolution methods, and display the problem resolution in a way that the developer could appreciate. A lack in any one hindered acceptance, and was problematic to development time and ultimate capability.

Problem resolution within the system was achieved by reduction of data sources and reduction of data entry. Incomplete storage of sessions was inherent in the shell environment. The ability for later completion was understood. Also, the dynamic data exchange (DDE) and client-server-control (CSC) together helped problem resolutions. (Appendix E contains listings of computer source files used as data to construct the knowledge base. Pages 1 through 4 of 7 contain an outline of the expert knowledge-base derived from C. P. Campbell's document Determining the cost effectiveness of training (Campbell, 1994)).

Development. The first problem associated with the knowledge base was how to represent the existing word processor format in the expert system shell. Most computer tools for information exchange assumed previous computer data base format. They did not allow for conversion of a word processor document with special formatting. If automatic conversion of a word processor document was possible, the conversion resulted in thousands of pages of segmented information. Each sentence or phrase was placed on a page by itself. There was no way to use a word processor document without extensive manual conversion to ASCII text. That conversion was laborious.

The source document Determining the cost effectiveness of training (Appendix A), first had to be converted to a universal format, American Standard Communication Information Interchange text (ASCII). The conversion process was supposed to be a mouse click away but when converted to

ASCII all formatting was lost. ASCII reduces the process to manual typing and much of the document had to be retyped. This manual manipulation of information tended to break down each time the document was reused. ASCII text uses carriage returns and line feeds like a typewriter. Manual reformatting was necessary in different applications software. Ultimately, the information was placed in two different media to allow student choice of path in the final developmental product.

A hyper-link text method called Viper Write™, by Looking Glass©, was the first media solution. Hyper-link was integrated to allow linking and embedding of information and immediate jumps to any part of the document. The second was a graphics presentation media Microsoft© Power Point™. While the expert development shell could do media tasks, the methods were not as efficient as other products. Pictures developed for use directly by Procedural Advisor™ were bit mapped only. Bit-mapped graphics consumed extensive computer memory and disk space. An entire presentation developed in a separate environment consumed less memory than one bit-mapped picture.

Different computer files were developed for every segment of the original textual knowledge-base. The file types were hyper-link, ASCII text, and graphics presentation. These were called (requested) by the development shell, as needed, when that part fit the needs of the finished product.

Hot Spots used in Procedural Advisor™ necessitated bit-mapped graphics. When a user clicked the mouse pointer on a Hot Spot, the click initiated a method or program. Hot Spots were necessary for jumps to a topic, launching other programs, and overall graphical simplification.

Ultimately, more files were developed than were used. Four sets of files were created from the original Word Perfect© text for use in the final presentation. The file extensions were

1. ASCII text (.txt)
2. Power Point™ (.ppt)
3. Viper Write™ (.hpw)
4. Bit mapped (.bmp)

Since the paper document included progress self-checks (tests), the computer version needed to have these. No commercially available products were found to facilitate the testing. A program was written using C programming language. The result was a program using ASCII with answer entry fields that did not allow one to back up after progressing to the next page. However, the second page immediately gave the proper answer from the previous page. The sequence was first page, question then user response; next page, answer feedback, then next question followed by user response.

For implementation of objective one, to develop the computer job-aid, seven steps were used. The first effort was learning Procedural Advisor™; the limitations became obvious. The second effort was the conversion of files from the original form. Initially, almost all efforts were futile. Many programs do similar tasks but the way they do them is not productive. Slowly, files were converted and built. The process started with the original Word Perfect™ 6.0 document Determining the cost effectiveness of training. ASCII text was the only form of text that was universal. ASCII was used when computer import filters failed. Third, computer files were converted from ASCII text to Viper Write™. Fourth, computer files were converted from ASCII text to Power Point™. Fifth, bit-mapped graphics files were created as they were needed for Hot Spots, etc. The process was labor intensive and not at all automatic. Sixth, the self check testing program was written. Last, the first version of Procedural Advisor™ was written. Each conversion took approximately three weeks. At times, system capacity was exceeded, and development was frustrating because of slow processing; speed and memory were always a problem. Efforts often took longer than desired. The total development was approximately 840 hours excluding final debugging and problem solving.

Special Methodology Used

The U. S. Air Force Instructional Systems Development (ISD) process facilitated the purposes of the study, through management, to demonstrate a better product. The ISD approach in five basic phases was: analysis (Figure 4 & 5), design (Figure 4 & 5), development (Figure 4 & 6), implementation (Figure 7), and control (evaluation). Figures 4-7 present flowcharts that represent the process followed.

The original knowledge developed by C. P. Campbell satisfied this process and embodied Instructional Systems Development (ISD) principles, and Criterion Referenced Performance measures. Criterion Referenced Performance was the desired result of training; with specific, and measurable human performance (Campbell, 1986). Objectives of the original material were derived from and instruction was built to achieve the measurable performance criteria. This research continued to follow the ISD approach, and the application of Criterion Referenced Performance.

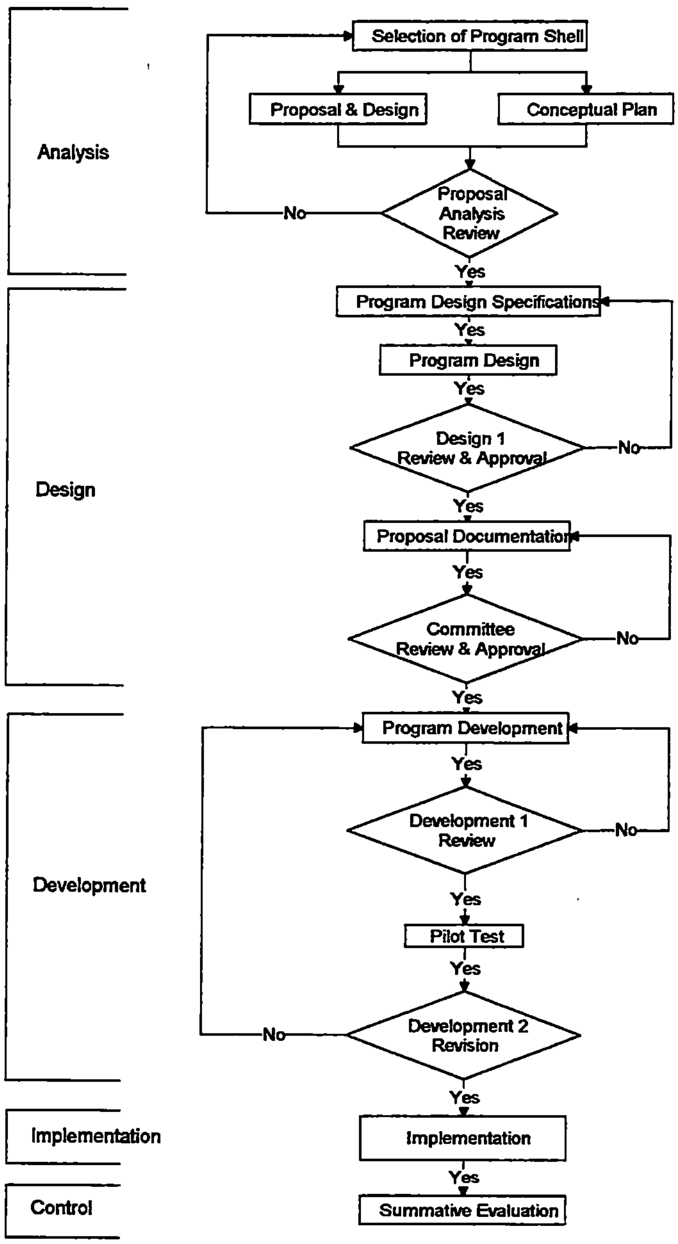


Figure 4. Implementation of ISD interactive training -- development process plan for software development.

Note. From "Interactive training development process," by Weaver, S. & Rosenthal, M., 1993, August, Paper presented at the TRADE meeting of the Department of Energy Training and Development, location unknown. Hanford, Washington: EG&G Energy Measurement Advanced Training Technologies Section.

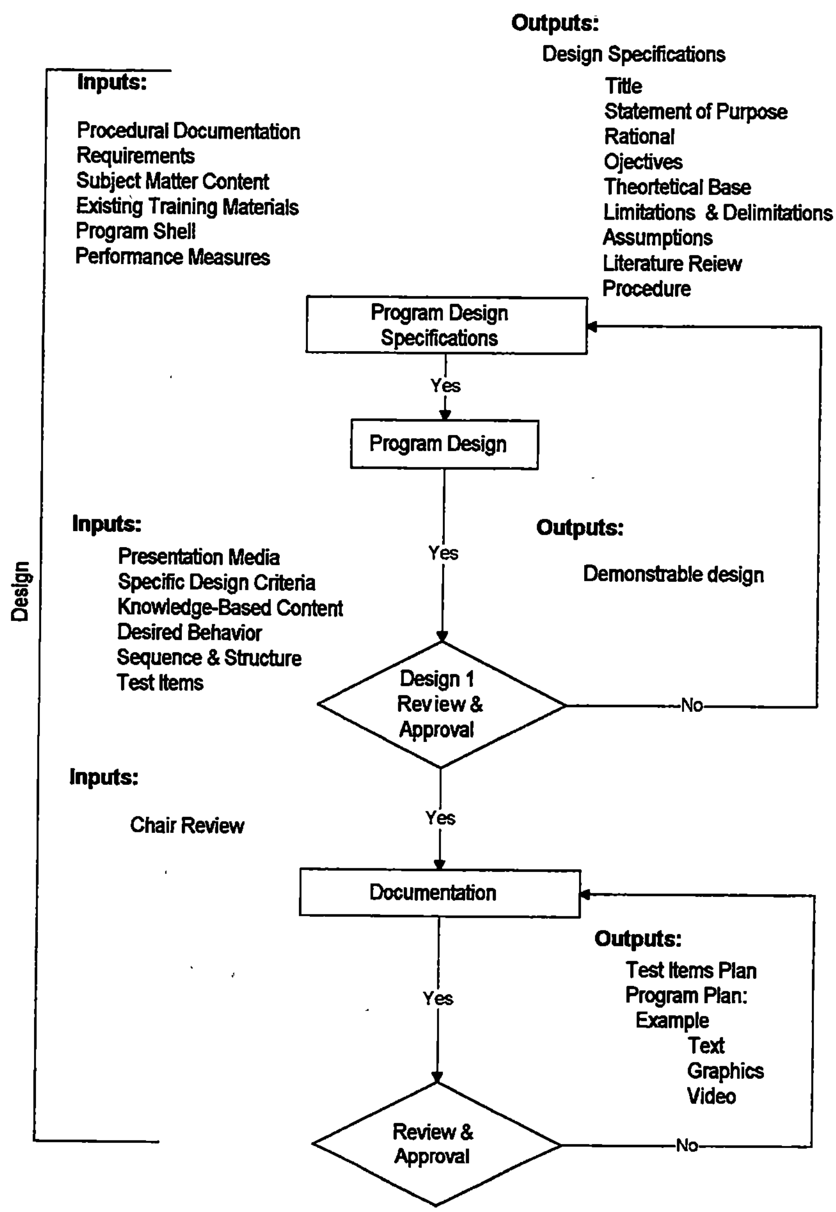
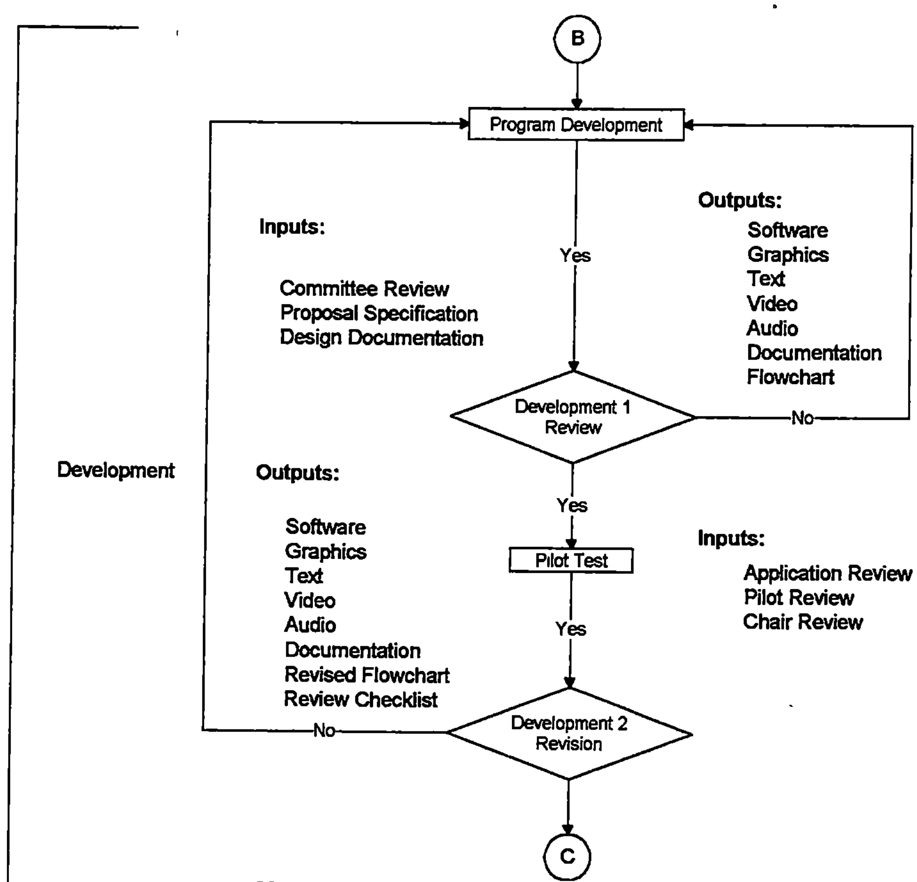


Figure 5. Adaptation -- design plan

Note. From "Interactive training development process," by Weaver, S. & Rosenthal, M., 1993, August, Paper presented at the TRADE meeting of the Department of Energy Training and Development, location unknown. Hanford, WA: EG&G Energy Measurement Advanced Training Technologies Section.



Checklist:

_____Does authoring include choice of presentation media?
_____Have changes in program content been documented?
_____Have design specifications been met?
_____Text screens – are they clear, spelling and punctuation corrected, layout appropriate and are the easy to read?
_____Other screens – are they neat, attractive, and well spaced?
_____Graphics and Video – are they distinct and well defined without blurring?
_____Narriation if used, is it clear, are terms pronounced properly, and is it free of distortion or noise?
_____Is style consistent between screens?

Figure 6. Adaptation -- development of Expert-Object Knowledge Transfer

Note. From "Interactive training development process," by Weaver, S. & Rosenthal, M., 1993, August, Paper presented at the TRADE meeting of the Department of Energy Training and Development, location unknown. Hanford, WA: EG&G Energy Measurement Advanced Training Technologies Section.

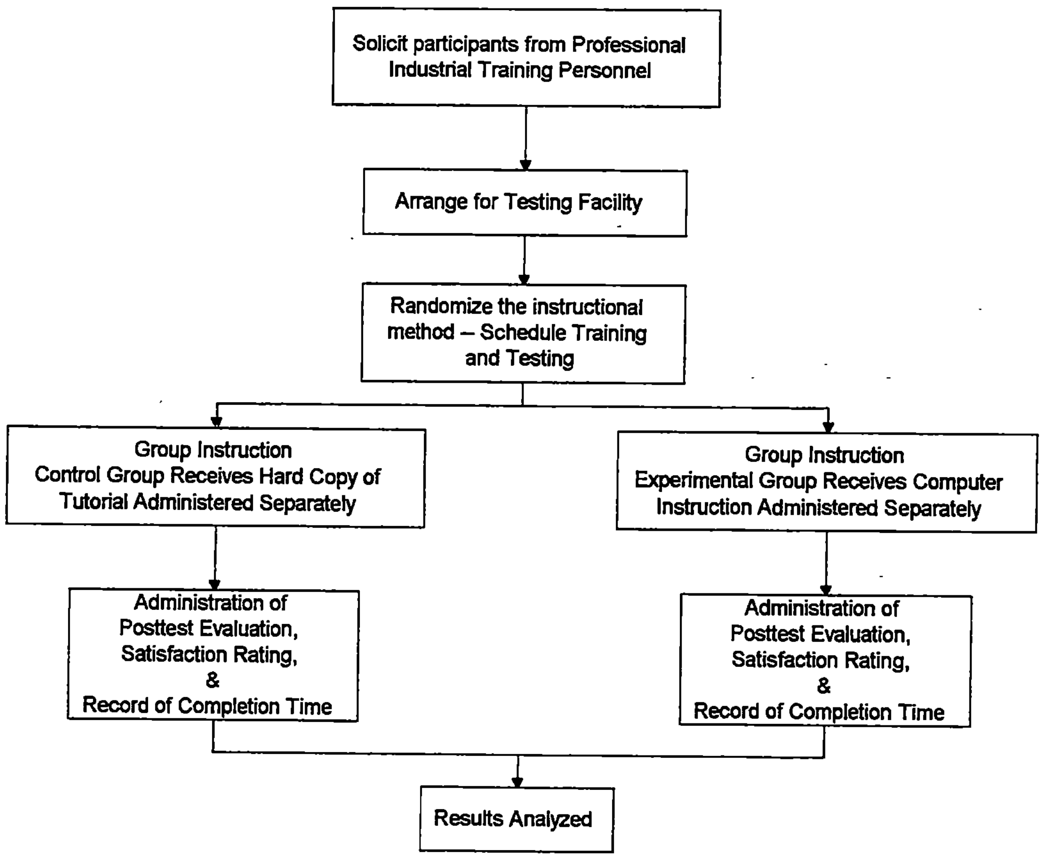


Figure 7. Test Effectiveness developed expert job-aids

<u>Pilot Test</u>

For satisfaction of objective two, to pilot test operation of the computer job-aid before administration of finished products, two consecutive pilot tests were conducted, including administration of evaluation instruments. These instruments were the satisfaction rating statements; and the progress test taken from the original work by C. P. Campbell. Testing conditions replicated true testing conditions.

The first pilot evaluated the operation of all instruments and computer development. The second pilot evaluated all instruments and the paper document written by C. P. Campbell. In both pilots the cognitive test and satisfaction survey instruments were administered.

Two committees of peers were used in the pilot. The two committees consisted of: 6 graduate students from those at the University of Tennessee, Knoxville, Department of Human Resource Development; and 4 students (industrial professionals) from Walters State Community College, Department of Industrial Technology.

The pilot-testing of job-aids and survey instruments were conducted in the spring of 1998 both at the University of Tennessee (UT) and Walters State Community College (WSCC). A group of 6 graduate students used the computerized expert-object job-aid. A group of 4 industrial professionals used the traditional paper instrument.

Persons using the computer (6 graduate students at UT) provided valuable error correction and feedback for improvement of the finished instrument. However, their posttest and questionnaire results were not conclusive because three of the six performed excellently on the posttest and three did not perform as well. Those who performed poorly left many blank responses on the posttest instruments used for information and data collection.

The purpose of the pilot was to evaluate the job-aids, the cognitive test, and the satisfaction rating; for discovery of unforeseen difficulties that allowed prior correction of the difficulty before administration to the final professional sample.

Those persons using the paper job-aid (4 students from WSCC -- professionals with industrial experience) provided administrative feedback, and error correction on survey forms and questionnaires. Since the paper job-aid had been previously edited and corrected, it proved satisfactory as written. The errors were in the researcher-generated instruments and were procedural, grammatical, and typographical. These results were evaluated closely. The following errors were reported by persons using the paper job-aid

1. Procedures on the human subjects disclosure
2. Procedures on the self-check tests
3. Grammar and spelling
4. Suggestion for individual calculators were noted
5. Wording
6. Sequence on the computer model
7. Administration methods
7. Training session on how to use the systems

Half of the pilot participants reported that they liked the instruments. However, half of each pilot group performed poorly on the cognitive test and/or the surveys. In fact, they made little effort to complete the instruments. Time was a factor; the first persons finished were eager to go home. Other factors were not stated and were not known. One must consider that the motivation of students with no prior interest. Additionally, the human subject disclosure emphasized no obligation. Either way the results were not conclusive for half of each group.

The participants reported that they thought the cognitive test to be adequate as written. Corrections were made to all developed instruments based on feedback and analysis of problems identified. The developed instruments were then considered acceptable.

<u>Population and Sample</u>

According to objective three, a posttest was conducted to compare the developed computer job-aid with the standard paper-based job-aid for industrial trainers. The test involved a sample of 24 professional, human resources, training persons. The trainers were selected from the industries in the immediate service area of Walters State Community College -- located in East Tennessee (Jefferson, Union, Sevier, Green, and Hamblin counties). The sampling type was a non-probability random cluster sample with random assignment of treatment. A large representative simple random sample of human resource training persons could not be obtained because of work schedules, availability of computer laboratory facilities and the time necessary for administration. From a cluster list of 100 industries in a 5 county area, 40 industries were chosen by luck of the draw. These industries included: construction, manufacturing, education, commerce, mining, and so forth. No criteria were specified. Participants were sent notification of free training on how to cost justify training. Volunteers were requested by fax and by telephone. The volunteers were randomly divided into two groups of 12 people each; 12 people for the control group (using conventional materials) and 12 for the experimental group (using computer based expert-object materials). Anonymity of participants was maintained. All attempts were made to control initial bias but may have failed where volunteers were required -- volunteers were required by the human subjects' procedure at the University of Tennessee.

In brief, from a cluster list of 100 industries, randomization was conducted in the choice of 40 industries from which 24 volunteers were solicited. Participants were then randomly assigned to one of two different groups of 12 participants each. Group-1 received the paper based version, and a comparison group-2 received a computer version of Determining the cost effectiveness of training, (total of 24 people).

All participants were informed that participation was not required. Additionally, they were assured that no names would be associated with any participant or participants' records. Two groups, 7 persons in each group, were tested at separate times, at Walters State Community College. Equal numbers, 5 persons, in each group were tested individually.

Research Design

A quasi-experimental design was used to demonstrate the effectiveness of the expert training job-aid using personal computer software versus traditional printed materials. The quasi-experimental design was a non-equivalent design -- a modification of Campbell and Stanley design number 10, without pretest and with random assignment of volunteers. The method was posttest only with two treatments. The posttest only design was allowed where other designs were impossible. The primary difference between this test and the pretest posttest design was the absence of a pretest, and absence of a random selection. As illustrated below (R) equals random assignment, X_1 equals the paper treatment, X_2 equals the computer treatment and O equals the posttest observations.

	X_1	O
(R)	---------------	
	X_2	O

This design unlike the experimental design lacked true randomization selection (the original cluster list and the volunteers). Consequently, the populations may have been different. The nonequivalent groups' design (design 10), allowed a comparison between groups. Group-1 (X_1) received the printed version of the tutorial; they did not receive the computerized job-aid. Group-2 (X_2) received the computerized version of an expert system job-aid. With this design no pretesting occurred before observation before posttesting. While the non-equivalent design is widely used in education, the posttest only design has been widely ignored. Such tests are permissible where subject matter is new or where new methods are employed (Stanley & Campbell, 1963, pp. 5-30).

Randomization, without a pretest, was adequate to assure lack of initial bias before posttest. Researcher control was used to reduce reactive effects of experimental arrangements that are the halo and hawthorn effect of environment versus attention. As part of the requirements of the University of Tennessee, the subjects were informed that they were part of an experiment. Human subjects' disclosure was also completed at the onset of administration (see Appendix B).

Instrumentation

Cognitive test. A content-specific cognitive test of 5 questions and 26 responses was used to test content retention and ability to use tools to get to the solutions. Two different job-aids were tested; one was computer based and the other was paper based. Both were versions of Determining the cost effectiveness of training (Appendix A). The same paper-based cognitive test was used for content evaluation of both job-aids as instructional instruments (Appendix C).

Test answers were weighted. Sixteen questions required response type-answers. These were given 2 points if the entire response was given (total 32 points). Some of these were in two parts. If any part was right 1 point was awarded. The 4 computation questions were given 4 points each (total 16). One point was given for the proper formula, 1 point was given for each of the proper numerator and denominator numeric values (total of 2 points), and 1 point was given for the correct answer. Six responses referred to methods, advantages, and disadvantages. Each response was weighted at 4 points (total 24). The maximum score possible was 72.

Satisfaction rating. The satisfaction rating instrument was developed as part of an internship at Oak Ridge National Labs (ORNL), Center for Training Technology. During the summer of 1994 a panel of experts from ORNL and the Center for Training Technology at Oak Ridge evaluated existing forms previously used for Department of Energy (DOE) Training at multiple Oak Ridge DOE sights. These forms were used either for assessment of electronic instruction or traditional instruction for evaluation of the participants' perception of instruction.

Several new statements and a new form were written to evaluate both the computer learning centers at ORNL and stand up instruction. Separately, existing dissertation satisfaction forms were evaluated during the summer of 1995; statements were rewritten. Originally there were 44 statements. These were reduced to 23 by eliminating similar questions and rewording. The product appears in Appendix D.

The satisfaction rating instrument in Appendix D was completed by all participants. The rating instrument was intended to compare student perception between the two methods of training -- the expert-object job-aid and traditional text with paper and pencil.

The satisfaction rating instrument used a Likert Scale of 1 through 9, where 1 is strongly disagree and 9 is strongly agree. Twenty-three statements were designed to examine perception of the participants to the training and the type of training. Twelve of the statements were negative statements inverted upon construction of the instrument. Accordingly, the answers had to be reversed before scoring. After the statements were written, they were assigned random order by luck of the draw.

Cognitive test and satisfaction scoring were conducted by a person outside the research (this person was trained in Education and Testing). The satisfaction rating instrument contained 23 statements and 12 human subjects per group. The total scores per statement ranged from a minimum of 23 (1 per statement) to a maximum of 108 (9 per statement). The composite score of all statements ranged from a minimum of 529 (minimum above x 23 statements) to a maximum of 2484 (maximum above x 23 statements). A professional was trained to score. This was done to reduce scoring bias. Green and beige colored score sheets were used to avoid confusion and to prevent mixing of data. Beige score sheets were for the computer cognitive test scores and green score sheets were used for paper cognitive test scores.

Treatment and Analysis

The tree structure programming methods used by the software development system and the subsequent evaluation proved beneficial (pilot; and cognitive test, completion time and satisfaction rating instrument). One problem of the developed computer method was systemic, the method or features of computer version self-check testing about which very little could be done. All grammar, typing, and procedural difficulties were generated by the researcher and were correctable.

The pilot was powerful and beneficial for corrective action and improvement of the developed computer job-aid and posttest instruments. Pilot-testing of the job-aids and instruments provided valuable feedback for error correction. Difficulty was found in procedures, grammar, spelling, wording, sequence, methods and lack of training for the computer method.

From objective three two groups of subjects were compared, computer versus paper job-aid, using descriptive statistical methods on independent variables comparing the mean values by standard deviation, histogram, and t-value. The paper job-aid was compared to the computer job-aid for

1. Difference in understanding and use of content
2. Difference in completion time
3. Difference in satisfaction

To test the job-aids, the treatment and analysis procedure in Figure 5 were conducted according to quasi-experimental methods given earlier under Research Design.

Instruction was administered at separate times through the computer job-aid and the paper-based instruction. When participants completed the instructional job-aid, the cognitive test was administered. After completion of the cognitive test, with a satisfaction scale, participants completed a rating instrument to evaluate instructional method and format.

Information was collected on the time for completion of the instructional materials, the cognitive test (Appendix C), and the satisfaction rating instrument (Appendix D). Completion times on both tests were maintained by the researcher. These times were recorded as the participants turned in their materials.

Due to the small sample size, voluntary sampling method and the posttest only quasi-experimental design, external validity, the degree to which conclusions may be generalized, was addressed by random assignment of testing methods, and uniform testing environment. The conclusions may be applied only to the immediate service area and industry of Walters State Community College in East Tennessee.

All attempts were made to eliminate or reduce cause-and-effect relationships and preserve internal validity. Internal validity was the degree to which the independent experimental variables (treatments) made a difference in the dependent variables (scores). Internal validity was addressed through randomization, experimental design, the posttest itself, and testing procedures. Internal validity depended on randomization, a proper test instrument, uniform treatment of participants, and uniformity of testing conditions. While all of these variables were considered, the population was small, restricted to the Walters State Service Area, and was voluntary, both by circumstances and by human subject requirements. Random imperfections may have occurred both in the instruments, and testing conditions; however, everything that could be controlled was believe to be controlled.

For analysis of mean scores, Campbell and Stanley suggested a t-test as optimal for this design. Descriptive statistics and an independent t-test were used at the .05 level of significance, on interval data derived from the Posttest performance, the time for completion, and satisfaction rating instrument.

Chapter IV

Comparison of Procedures and Results

Objective one allowed for development of a computer job-aid for instruction of industrial trainers, using an object-based expert system. A synopsis of that expert job-aid is included in this chapter. Objective two allowed for a pilot-test to check operation of the computer job-aid. The pilot-test is detailed in chapter three along with instructional development methods. Objective three allowed for the comparative analysis, using human subjects, of the developed computer job-aid with the standard paper-based (hard copy) job-aid for (a.) content understanding and use, (b.) completion time, and (c.) participant satisfaction. This comparison of Procedures primarily emphasizes objective three from administration of the job-aids through statistical analysis of posttest instruments and comparison of results.

Administration and implementation of the job-aids for research and future analysis, occurred from May through November of 1998. The duration of the study resulted, in part, from difficulty in scheduling professional industrial people. It was especially difficult to schedule the group at a common time, in a common place. External validity was suspect because of the selection of professional industrial people, instructional setting, testing time. These variables were addressed by maintaining randomization and uniformity, when they were possible. No assumptions were made about inherent diversity or responsiveness of the population.

To facilitate the organization, transfer and separation of data colored sheets were used for raw data and scoring. Beige color was used for computer data and green color for paper data. Tables used for collection of data proved beneficial to aid the maintenance of data purity.

Expert System Job-Aid

The study compared a computer job-aid with a paper job-aid. While no development was necessary on the paper job-aid, the computer job-aid required a total development.

The computer methods used for development of the computer job-aid emphasized models of the original knowledge. The application and the management of such knowledge in the computer application were problematic.

The computer job-aid contained freedom of instructional method and choice knowledge path. Both a hyper-link path and a graphics path were provided for selection by the user. Content was consistently maintained between the computer paths and paper job-aids.

Originally, the computer job-aid had video and audio included. However, the institutional computers available for testing were not yet set up with audio and video capability. Both audio and video were eliminated before pilot testing. (Unless head phones are available audio tends to disturb other students. Video compatibility varied by system due to the required software drivers for that system -- universal standards were changing).

Participants Demographics

Four questions were prepared to determine participants educational background and application experience in training, as seen in Table 2. These were administered at the conclusion of the posttest. Responses were requested in months then converted to years. These questions contrasted formal educational preparation with training applications and experience. There were no significant differences between those who took the computer method and those who took the paper method when mean scores were compared using the independent t-test.

Relationships between the table-t value were negative with the persons using the computer method showing slightly less educational preparation and applied experience in each of the four categories.

Table 2. Independent t-test pair wise comparison of demographics -- participants' preparation and experience in training, and instruction in **years**.

Educational preparation and application experience	Number of subjects	Mean computer	Mean paper	Std. Dev. Computer	Std. Dev. Paper	t-value
1. Planning and preparation of instruction	22	3.5	2.1	2.1	.5	-0.153
2. Training implementation	22	3.3	3.4	1.9	1.7	-0.023
3. Instructional methods	22	3.9	4.2	.86	1.8	0.249
4. Cost analysis	22	1.2	1.6	.4	.6	-0.903

Note. *p*. .05 > 2.07 (with 22 degrees of freedom)

Mean education and applied experience ranged from more than one year to more than four years. The distinctions between the groups were seen in comparison of standard deviation from the mean on item one where the computer group distribution was platykurtic and item three where the paper group distribution was platykurtic. Standard deviations of the other distributions were nearly the same.

Job-Aids Comparison Results

The first part of objective 3 required the comparison of job-aids for understanding and use of content. This required administration of the job-aids to human subjects. The posttest followed the administration of job-aids. A population of 24 industrial training persons was solicited to test the performance of the job-aids. These persons were randomly assigned to two groups of 12 persons. One group received the paper job-aid and one group received the expert system job-aid. When the participants finished the job-aid they took the posttest. The posttest was used to gather data for comparison.

Statistically the cognitive test scores (dependent variables) resulting from posttest must:

1. Come from two separate groups and have different treatments (independent variables) one of which is a known method (treatment such as paper job-aid) and one of which is the method (treatment such as computer job-aid) under investigation (study).

2. Have distributions (measures) with a mean (average) and variation (deviation from the mean) as shown by the range, and standard deviation.

For an assessed treatment effect to have significance, the statistical or non-chance difference between the groups' means must account for the spread, range, or variation from the mean (see Figure 8). Thus, one must mathematically divide the <u>difference between the groups means</u> by the

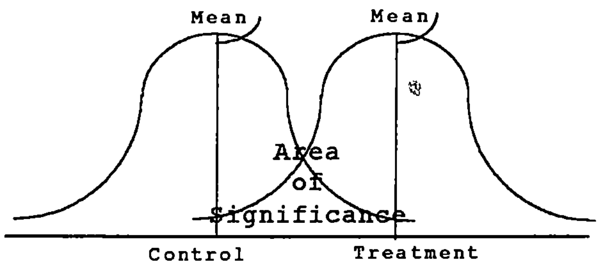


Figure 8. Distribution and distribution location.

For comparison and significance, one must note the spread of the curves (kurtosis), the overlap of the curves (area of significance) and the difference between the means. If the means are close together and the overlap is great, then the significance is low. A wide flat (platykurtic) distribution may appear to be less significant and a skinny peaked (leptokurtic) spread may appear to be more significant; when in fact the mean values may have the same difference (may not have changed values).

variability of the groups (signal to noise ratio) -- the mean = signal and the spread = noise.

Understanding and use of content (item a of objective 3). The results of the statistical analysis of the cognitive test raw scores are seen in Table 3. Most of the values were nearly equivalent, between the experimental variable versus the control variable. The maximum possible score was 72. The cognitive test scores for the experimental group (Computer method) ranged from 33 to 71. The cognitive test scores on the control (Paper method) range from 29 to 71.

Table 3. Independent t-test on cognitive test -- computer versus paper treatments. Maximum possible score = 72.

Sources of rating	Number of subjects	Mean rating	Standard deviation	t
Computer	12	58.44	12.0	-0.083
Paper	12	58.86	12.5	

Note. $p_{.05} > 2.074$ (with 22 degrees of freedom)

The mean cognitive test scores were 58.44 on the experimental method and 58.86 on the control method. Figures 9, 10, and 11, show that the computer plots appear nearly normal. However, the standard deviation from the mean was 12.0 for the computer and 12.5 for the paper. Approximately 66% of all scores for both groups were within upper standard deviation (+1 SD of the means). The upper limits of the raw scores (72) almost fell within +1 SD of the mean values. The distributions of cognitive test scores were not normal in truth they had a J-shaped curve with the majority of scores at the high side of the range.

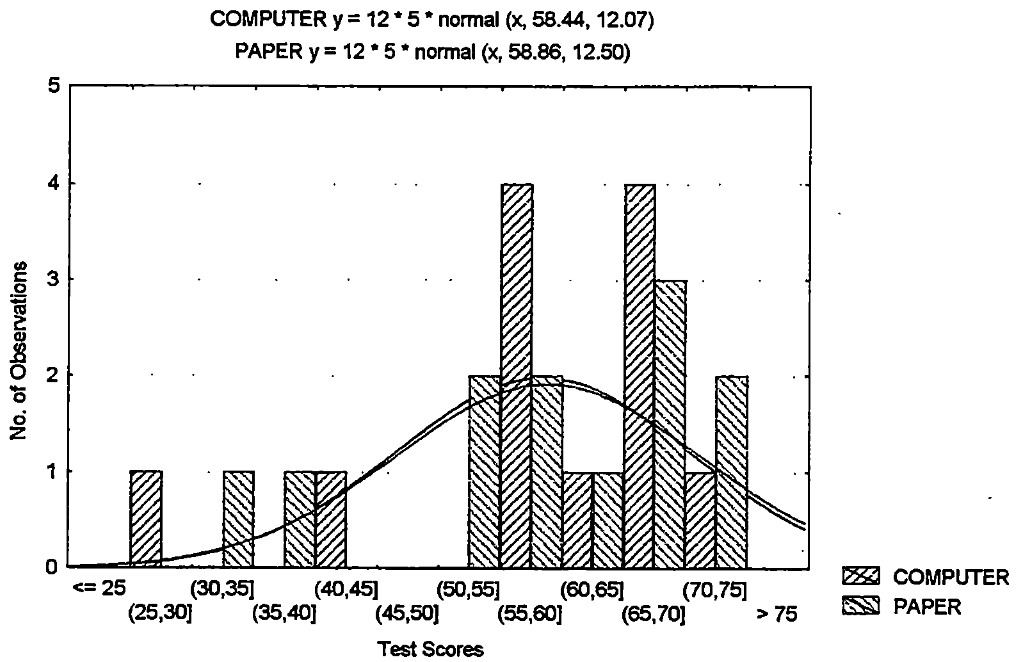


Figure 9. Cognitive test histogram and distribution of computer vs. paper score.

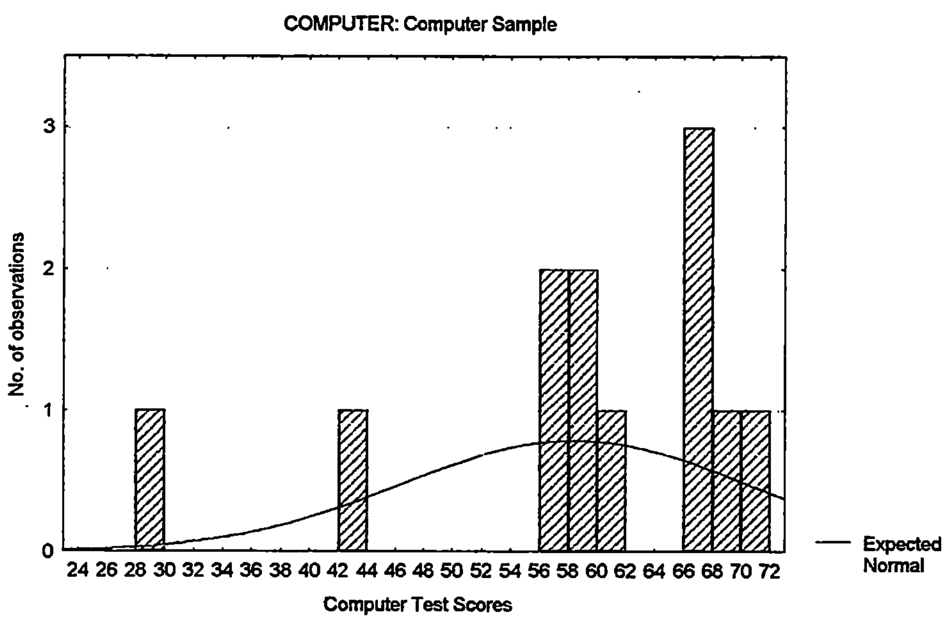


Figure 10. Cognitive test histogram and distribution of computer score.

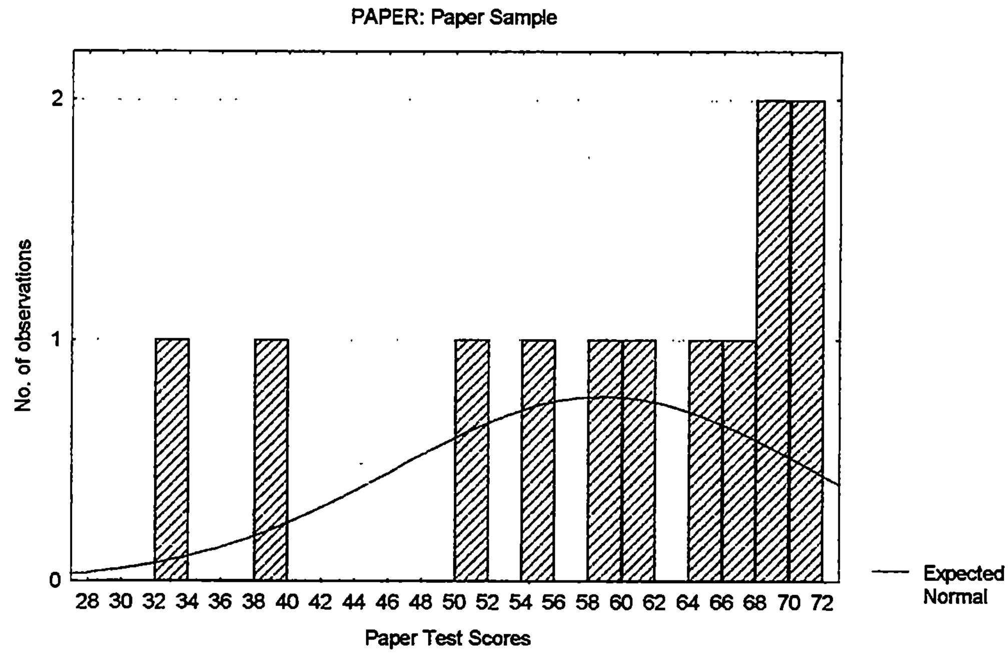


Figure 11. Cognitive test histogram and distribution of paper score.

The t-test on the means of the cognitive test scores did not indicate a difference between those persons using the computer job-aid and those persons using the paper job-aid. When the means were calculated, a t-value of -.08 was returned; the t-value was not significant. To be significant at the .05 level, with 22 degrees of freedom (df), the t-value should have been 2.07 or greater. Both the computer and paper methods were equally effective methods of instruction, as evidenced by graphical distribution and t-values on the means of cognitive test scores.

Completion time. The paper method took less time to complete than did the computer method (see Figure 12). The histogram plot visually indicated a difference between the mean scores on the completion times of the computer method and the paper method. The computer method means scores were 2.5 hours versus mean scores of 2 hours for the paper method. Table 4 showed the calculated values. The variance and range were greater for the completion time on the paper method than on the computer method. In fact the paper method spread (1.48 to 3.16) almost included the computer method spread (1.91 to 3.33). The distribution of scores was nearly normal on the computer method, but slightly more positively skewed on the paper method; because of the spread. In general the computer method took half an hour longer to complete versus the paper method. The distributions of scores were wider for the paper method; some of the participants took much less time to complete the job-aid and some participants took almost as long to finish as those on the computer method.

The t-value indicated a difference between the completion times on the computer job-aid as compared to the paper job-aid. The paper method took less time to complete than the computer method. The calculated t-value was 2.46 and probability at .05 indicated that the t-value must be greater than 2.07 to have a statistically significant

Table 4. Independent t-test for time to complete the computer method versus the paper method

Source of rating	Number of subjects	Mean rating	Standard deviation	t
Time Computer	12	2.51	0.37	2.46*
Time Paper	12	2.09	0.47	

Note. p.05 > 2.047 (with 22 degrees of freedom)

*Significant at .05 level of significance

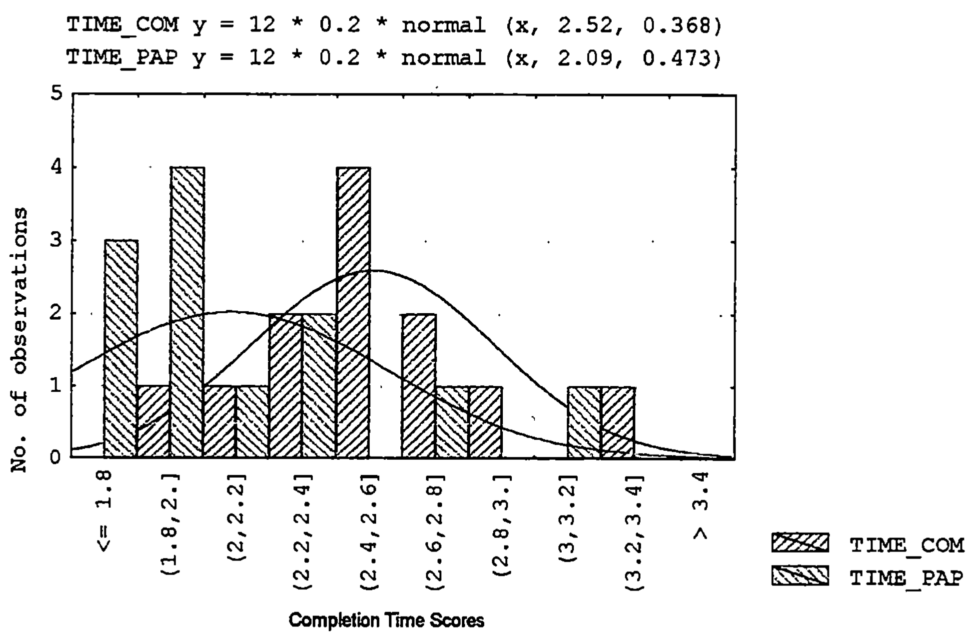


Figure 12. Histogram of completion times for cognitive test

difference (p .05 > 2.07). The calculated t-value 2.46 is greater than 2.07, the computer method took more time (2.5 hours versus 2 hours).

Satisfaction. The satisfaction scale was a 9-point Likert scale; where 1 was strongly disagree and 9 was strongly agree. The satisfaction rating instrument on instructional methods used 23 statements. Analysis between the responses of the two treatment groups, of 12 persons each, was examined using two different approaches. The first compared each statement by total, on each of 12 responses to an individual question (minimum score of 12 and maximum score of 108). Each statement was a composite score. Then each statement was treated as a variable for 23 items (23 statements) in two groups. The t-test was calculated on group means. A second test looked pair wise by statement. The means of each of 12 responses were calculated separately, computer versus paper. The calculated means then were compared, one statement at a time, using a t-test (minimum score of 1 and maximum score of 9, by statement).

A t-test was performed on summed composite of each satisfaction statement (total of each statement separately by method). The computer method was more satisfying than the paper method. With 44 degrees of freedom at the .05 level of probability the t-value was supposed to be 2.01 or greater.

The calculated t-value as shown in Table 5 was 2.07. which is greater than 2.01 and is statistically significant -- the computer method was more satisfying than the paper method.

From the satisfaction rating instrument separate t-tests were calculated using mean scores on each of 23 pairs of statements. Next the mean values of statements were compared by pairs, comparing the computer satisfaction

Table 5. Independent t-test of the satisfaction statement totals for job-aid on the computer method versus the paper method.

Source of rating	Number of statements	Mean of totals	Degrees of freedom	Standard deviation	t
Computer	23	83.39*	44	7.20*	2.07*
Paper	23	79.22*	44	6.43*	

Note. p.05 > 2.01 (with 44 degrees of freedom
*Significant at .05 level of significance

versus paper satisfaction, using a t-test, on statements 1 through 23. The satisfaction scale was a 9-point Likert scale; where 1 was strongly disagree and 9 was strongly agree. Only the following two statements showed a significant difference when analyzed.

5. Provided for my individual difference in learning style.

6. Emphasized identifiable main goals for me.

On statement 5 and 6 with 22 degrees of freedom at the .05 level of probability for a difference to exist, the t-value must be 2.07 or greater. On statement 5, persons taking the computer method were more inclined to believe that the system allowed for a difference in learning style -- the t-value of 2.38 was greater than the required 2.07. On statement 6 persons taking the computer method were more inclined to believe that the system better emphasized identifiable main goals -- the t-value of 2.60 was greater than the required 2.07. As shown in Table 6, those that took the computer method were more strongly in agreement on these two statements, than those taking the paper method.

An individual analysis of the statements revealed seven statements with a neutral or negative relationship between the variables. On these statements, the mean of the paper method was equal or higher than the mean of the computer method. Those statements are indicated with an <u>asterisk</u> in Table 7. The mean of the remaining statements for the computer method tended to be positive in relationship to the paper method.

Table 6. Independent t-test pair wise comparison of participants' satisfaction on computer versus paper.

Source of rating	Number of subjects	Mean computer	Mean paper	t value	Standard deviation computer	Standard deviation paper
1	12	7.08	6.25	1.61	1.50	0.96
2	12	6.83	6.58	0.39	1.69	1.37
3	**12**	**6.50**	**6.83**	**-0.33**	**2.81**	**2.81**
4	12	7.50	6.83	1.03	1.50	1.64
5	***12***	***7.17***	***5.33***	***2.38****	***1.33***	***2.30***
6	***12***	***8.00***	***6.67***	***2.60****	***0.85***	***1.55***
7	12	7.50	7.25	0.44	1.44	1.28
8	12	6.92	5.92	1.21	1.78	2.23
9	12	7.42	7.08	0.70	1.31	0.99
10	12	7.92	7.42	0.98	1.08	1.37
11	12	7.17	6.58	0.90	1.64	1.50
12	12	6.67	5.75	1.21	1.61	2.05
13	12	6.75	6.00	0.72	2.59	2.44
14	**12**	**6.42**	**6.92**	**-0.83**	**1.72**	**1.16**
15	**12**	**6.41**	**6.58**	**-2.76**	**1.78**	**1.08**
16	**12**	**5.83**	**6.75**	**-1.12**	**2.31**	**1.60**
17	12	7.17	6.25	2.06	0.71	1.35
18	**12**	**6.50**	**6.50**	**0.00**	**6.50**	**7.25**
19	**12**	**6.50**	**7.25**	**-1.41**	**1.24**	**1.35**
20	12	7.17	7.08	0.13	1.33	1.62
21	12	7.42	7.25	0.31	1.16	1.42
22	**12**	**5.58**	**6.67**	**-0.12**	**2.50**	**1.66**
23	12	7.42	6.08	1.46	1.92	2.50

Note. $P_{.05} > 2.074$ (with 22 degrees of freedom)

*Significant at .05 level of significance

Table 7. Satisfaction statements with the means converted to percentage.

Number	Com %	Pap %	Statements from the Satisfaction Rating Instrument
1	79	69	was satisfying to me once completed
2	**76**	**73**	**limited my opportunity for observation**
3*	**76**	**76**	**did not teach knowledge and skills together**
4	**83**	**76**	**provided me with unsatisfactory task explanations**
5	*80*	*59*	*provided for my individual difference in learning style*
6	*89*	*74*	*emphasized identifiable main goals for me*
7	**86**	**80**	**allowed no opportunity for me to conform to the instructional method**
8	**77**	**66**	**did not provide me an alternate path for learning**
9	82	79	developed a working vocabulary as I progressed
10	88	82	emphasized learning, through practice, learning by doing
11	**80**	**75**	**did not include training for me on specifics**
12	**77**	**60**	**did not maximize my own performance**
13	**75**	**67**	**was frustrating to me**
14*	71	77	encouraged me with helps
15*	71	73	was adaptable to meet my individual needs
16*	**65**	**75**	**required excessive effort for the benefits I received**
17	80	69	embedded learning in the application environment
18*	73	73	created an expert model for me to follow
19*	73	80	provided me with continuous support throughout the process
20	86	79	allowed me to acquire experience
21	**82**	**81**	**was an unsatisfactory presentation format for my particular situation**
22*	**65**	**74**	**limited my learning by restriction of interaction between administrators and myself**
23	**82**	**68**	**I prefer paper to computers**

Note. **Com** = computer means satisfaction %.
Pap = paper means satisfaction %.
* = negative relationship computer to paper.
Embolden = negative statements inverted to positive for scoring.

While the computer version tended to take half an hour longer than the paper version, persons using the computer method, on the statements listed by number below, tended to respond more positively

1. Satisfaction

2. Observation opportunity

4. Task explanations

5. Provisions for individual difference in learning style

6. Emphasis on main goals

7. Opportunity to conform to the instructional method

8. Provision for alternate path to learning

9. Development of working vocabulary

10. Emphasis on learning, through practice, by doing

11. Training on specifics

12. Maximizing performance

13. Lack of frustration

17. Embedding of learning in the application environment

20. Provision for acquisition of experience

23. Preference of computer to paper

The paper method took half an hour less time to complete. The persons taking the paper method tended to respond positively to:

14. Encouragement with helps

15. Ability to meet individual needs

16. Amount of effort versus benefits

19. Provided me with continuous support throughout the process

22. Limitation of learning by restriction of interaction with the administrator

The responses to these statements may not have been a positive for the paper method but a negative reaction against the computer method. It is possible that the computer responses were low because of frustration on features or lack of them.

Statements 3 and 18 were equal and 21 nearly equal, with no advantage between the two methods:

3. Teaching of knowledge and skills together

18. Expert model

21. Satisfaction on format for the learning situation

Summary of Procedures and Results

There was no significant difference between the computer method and the paper method for understanding and use of content based on cognitive test scores. The results of the cognitive test for both methods tended to cluster high; indicating either bias in scoring or excellent performance on both job-aids.

The time for completion required for the computer method was greater than that required for the paper method. The paper method took .5 hour less time to complete (2 hours) than the computer method (2.5 hours).

Overall, participants who took the computer method were more satisfied than those who took the paper method. The t-value on total of all satisfaction scores and the average of response means for satisfaction rating instruments showed more satisfaction on the computer method.

Chapter V

Discussion of Findings and Recommendations

The purpose of this study was to develop a computer job-aid from a hard copy version, for industrial trainers, using an object-based expert-system and to test the effectiveness of the resulting training process against the paper-based (hard copy) version. Objectives were met which included development, pilot-testing, and comparison. The comparison looked at content understanding and use, completion time, and satisfaction.

Object technology and expert systems were found to be mutually dependent on one another for achieving effective applications. Together they allow for development of complex, real world, expert information with interrelationships.

Compared to other methods expert object technology increased potential and reduced limitations. However, development time was still extensive and cost was high. Time was reduced to 840 hours to complete a working model. Software modules were found to be reusable upon request. Components were transportable. Software was more affordable but was not cheap. Problems still existed and effectiveness was limited by development time and cost.

Limitations were compounded with a continuous need to support changes in hardware, and software. Upgrades to operating systems, and development programs created a need to modify the expert system. Hardware systems including disk space and memory required change to run the new software. Other changes came from destructive effects such as power surges and virus. These were application problems, and they reflected on the development environment and the end product. Thus development support became a problem through upgrades and continuous change.

Before implementation of this study, choices were made to address difficulty, and to avoid those difficulties. Regardless problems were encountered that were not supposed to exist. Research and selection were biased. The supporting software and technology lacked features, and was not yet a comprehensive system.

Findings

Development. The expert system shell Emerald© Procedural Advisor™ excluded graphics and text development tools, features now reported to be standard. This resulted in a need to use several other tools to convert text, develop graphics, and represent knowledge. The necessity of learning other programs compounded adding difficulty to an otherwise simple process.

Excluding external development tools such as Microsoft® Paintbrush© and Powerpoint©, and Shapeware™ Visio©, other tools were needed for text and for graphics. Two other programs were running under the expert environment. One was a hyper-link program for text and the other a graphics presentation program. While the expert software would handle bit-mapped graphics directly, one screen could take more than one megabyte (1,000,000 bytes) of disk storage. The bit-mapped graphics were awkward to develop and required manual manipulation. Often resolution was lost in conversion. If a change was needed the picture had to be externally manipulated with other graphics tools. The absence of integrated hyper-link text tools and graphics tools made development more difficult.

While development problems were greatly reduced, the kinds of problems experience during this study have traditionally plagued expert system development. The early version of Emerald® Procedural Advisor™ software used here was a vast improvement over those previous tools but inadequacies detracted directly from the subsequent development. (At the time of this writing the expert development shell was dated and much newer software was available from Emerald Intelligence®.) Regardless, the software features were more than adequate.

The tree branching methods used for programming in Procedural Advisor© proved to be both agreeable and simple. Execution of other programs from within Emerald© Procedural Advisor™ was straight-forward. Programming for systems development was a vast improvement over other methods. Previously, computer code had to be developed line by line. Procedural Advisor™ used objects for programming. While execution code could be used and embedded, it was not necessary. Tables were placed in the program tree by a click of the mouse and then filled in with requisite information or data. These methods were usual in object programming.

The development occupied seven phases

1. Learn Emerald Empower© Procedural Advisor™
2. Convert files to ASCII
3. Build Viper Write™ Hyper-Link files
4. Develop Power Point©
5. Create Bit Mapped graphics
6. Write self check computer testing program
7. Write Procedural Advisor™ program

Time could have been reduced if an integrated set of tools were available. Instead, because the system would accept them, ASCII text and bit-mapped graphics they were used. All conversions or manipulations were time consuming and awkward. These common problems and were experienced by many software systems.

The developed system was intended to examine or demonstrate a limited number of characteristics and potentialities. After application, the researcher submits that the system met or exceeded the following:

Software included inherent use of the knowledge-base derived from subject authority or heuristic expert. The software was intended for problem solving.

Since the software was a procedural tool with tree programming, task development could occur within the software environment.

- Other programs could be launched by clicking on a graphic item or area, consequently these were intelligent graphics.
- The environment proliferated with "drag-and-drop" programming or object system methods.
- Reduced complexity was definitely present but improvement was needed for single person development.
- Flexibility was limited only by the imagination and technical ability of the user. The system itself provided tools without adequate explanation of possibilities.
- Efficiency was apparent from the tree environment and the expanded features. Many of these were not used.
- Nonlinear paths were a noticeable part of the

development environment and the subsequent system.

- The central feature of the software development environment was branching methods. The programming method was through a tree structure. Subsequently, the end product used branching methods.

- Interactivity was found in the query process which evoked the user to respond and in place holders which allowed user choice for path retracing.

- Exploratory jumps to topic by graphical guides were allowed by hot spots. Path retracing through the environment was provided by place holders. A simple click on a picture of a topic provided learning excursions, answers, or alternate paths for the user.

- One desirable feature of the system was its ability to track development through sessions save features and generate a record of progress (self-documentation).

- Use of subsystems was inherent in the development tool, through alternate program firing, linking, and embedding.

- Information tracking was facilitated with place holders, path retracing, and the procedural nature of the environment.

- Compared to earlier efforts, development time was considerably less. Features were achieved with this development that took teams of programmers to achieve in earlier systems.

- Reusable software frames or modules as seen in the tree programming and recall of previously built subsystems.

After development some features were found to be missing or lacking or could have been better supported in the development environment. Either the resulting developmental product or Emerald© Procedural Advisor™, seemed to lack the following:

- Implementation was not cost effective because of the ad hock subsystems and programs that were necessary for proper development. In fact the program itself cost $10,000.
- Easier maintenance was likely through object methods but maintenance in general was found to be difficult.
- Reduced technical problems were not necessarily part of the system. Technical problems seem to follow complex systems. The version used in this research had a number of technical problems.
- Goal orientation was not addressed because the achievement of an abstraction implies intelligence and is rooted in philosophy, strategy, and execution of these. While a system may meet these attributes, the degree is inherent in the mind of the creator of the system and not in the system itself. While this paper at times implied the

opposite, goal orientation is a human attribute and is rejected ultimately.

- Knowledge resource allocation and presentation methods were often limited by the system structure in the programming environment. Total flexibility was never intended and was not available.

- There were no provisions for apparent intelligence (no inference engine) for rule matching or mathematical implication.

- The final product was not capable of modeling human thought and subsequently one may not suggest that the learner was an expert learner.

- Knowledge distribution through documents, drawings, video and user service were a strong part of the development system capability but they were not fully utilized because the systems needed to reproduce them were not available or were limited (available computer facilities).

Pilot. Pilot procedures improve the product through feedback and error correction. These are necessary features in any system. For this research, without the pilot study, problems would have gone undetected.

Persons taking the pilot noted those difficulties that seemed appropriate but from their view point were inappropriate. Also, they could detect spelling, word usage, grammar and other common problems previously undetected.

From observation, some in the pilot group seemed confused by computer systems in general. These persons seemed to want pre-chosen paths through the development system. However this was an expert knowledge based development and some user choice was necessary. Also, the system had path retracing and automatic rewind to the beginning. When the system automatically rewound participants were unnerved. When they had to retrace a path to the beginning on their own, they seemed to become agitated.

Given the choice of graphics path or hyper-text path only one person looked at the text path. That person ultimately used the graphics methods and reported confusion in the text. This text was identical to the paper method. Otherwise all persons used the graphics path -- none chose the text path.

Some participants did not complete all the instruments administered during the pilot. Consequently, problems could have gone undetected. Regardless, the exercise of administration itself revealed difficulties previously undetected. Additionally, the pilot proved to be valuable for correction of the administration process, and for the technical accuracy of the instruments.

Summary of job-aid findings. When the paper job-aid was compared to the computer job-aid

1. No significant difference was found in understanding and use of material

2. Completion time was significantly different, with computer taking significantly more time than the paper

3. Satisfaction was significantly different, with the computer being more satisfying than the paper.

Discussion of Findings

From inception to completion of this study an entire decade has been spanned. During that time personal computer systems have gone from promise to delivery. However, enterprises are not yet finding the earth shaking changes predicted. At the time of this writing the typical industrial manufacturing public for which the study was intended has not yet responded beyond the scope of the study for manufacturing systems. Indications are that the industries are having difficulty with funding and with technical skills of managers and work force. Industries that try to incorporate technology into systems find costs, time, and usability of the end product continuous problems. When a system is ready to install (these systems may easily take years to develop) that system may be obsolete. These problems were found during this study.

Methods have improved toward elimination of problems. Advantages demonstrated were in the methods and were compared to conventional line code programming. Methods indicated development has improved to the point that limitations are reduced and finished products are possible by single individuals. This study was believed to demonstrate 16 of the 24 traits listed in chapter 1. Demonstrated were: the use of the subject authority, task development in the knowledge base, intelligent graphics, object methods, reduced complexity, flexibility, efficiency, non-linear systems, branching methods, interactivity, exploratory nature, tracking through path tracing, self-documentation, use of subsystems, reduced development time, and reusable software frames.

Eight traits were not believed to be demonstrated. They were: cost effectiveness, easier maintenance, reduced technical problems, goal orientation, knowledge resource allocation for information and presentation, apparent intelligence, human thought model, and distribution of resources in video, audio, and drawings. While demonstration of these may have been possible, time and hardware availability hampered their inclusion.

The pilot study process was productive. Problems and anomalies were returned that otherwise would have gone undetected. Without the pilot, much less would have been known and improvements would not have been incorporated in the product. Additionally, procedural administrative problems may have gone undetected. The pilot provided administrative understanding and a forum for comment and correction.

The investment for development of computer instruction must be considered with caution. There is an extensive cost in software, hardware, development time and administration time. The costs incurred for this development very nearly approached $15,000. Software was $11,000, and computer hardware approached $4,000. This does not include direct and indirect costs of labor.

The computer development alone took 840 hours. Since either data-base development, tree development, or the text development preceded a fully automated computer knowledge development, the times become additive. The total time invested is the sum of all times.

Because the persons taking the paper method performed at least as well as the ones taking the computer method, unless there is some other requirement than knowledge transfer such as electronic accessibility of documents, computer development may be unnecessary. This is to conclude that all developments arrive at the same results as this study.

Extra time was needed to administer the computer method (.5 hours more time to complete) as compared to the paper method. Consequently, computer applications may not have a time-saving factor. However, many computer tutorials have reported time savings. Future research and documentation are needed to verify time concerns of computer training.

Computer developments may have an overall positive benefit in the perception of the user. The users in this study perceived satisfaction in the computer training paradigm. Satisfaction alone does not equate to improved understanding and satisfaction alone may not provide justification for computer developments but is note worthy for future studies.

Consequently, object-based expert systems development has shown progress toward reduction of problems including cost, time, and usability. Unfortunately, problems still existed during this study. They are believed to continue as each new operating system requires a new computer, new development software and other upgrades to run under the new system. Such systems show little evidence of becoming subtle. Advances in communication technology for the internet may change this.

Flexibility was evidenced and supported in graphics, text, availability of audio and video and programming methods. These were not yet efficient for demonstration of knowledge. For example, during administration of the finished development, availability of computer systems that could reproduce them was a problem. Reductions in systems cost and rapid technological advances were expected to reduce limitations. One can fully expect that other limitations of this study will be or have been reduced.

This study was limited in ability to conclude universal implications. The pilot groups and the main study sample were both small regional groups. However, some conclusions were possible. We can determine that pilot groups were beneficial. Also, computer based expert systems allow active participation, and provide for application but we cannot determine to what extent. Nor can we determine if they are improved over paper methods and we can conclude that the persons taking the different methods preferred computer methods over paper methods. Evidence suggests that more marked differences should be found.

Reaction and Consideration

This developmental study used a small sample posttest only quasi-experimental design. The sample was taken regionally and it was voluntary. Any inferences are for the region area of the study only. There has been no follow up to the users of the computer version of the job-aid. Persons taking the computer job-aid seemed to believe that the computer better allowed for individual difference in learning style and emphasis of main goals. Perhaps individual difference in learning style was addressed in the computer model with multiple paths and choice of methods. Both a graphics path and a hyper-text path were available. Both allowed path retracing and both methods were self supporting. Whether these allowed for differences in learning style is unclear.

How computer job-aid better emphasized main goals are also unclear. All computer methods were taken from the same paper material. The computer methods modeled the paper job-aid. Organization was essentially the same and the text and tables were identically the same. Perhaps automatic path retracing to the main topics' screen drew attention to the main topics. Since anonymity was maintained on this study, follow up to the computer users was impossible. Such follow up is suggested in future research.

Statistical analysis indicated no statistical difference in the cognitive test scores between the computer job-aid and the paper job-aid. Since the groups were statistically uniform and homogenous, the scores should be the same unless the computer methods allowed some advantage such as automatic prompting, self-calculation, or some other feature or difficulty not available through paper methods. Literature indicated that a difference should be possible. Future research needs to consider the identification of methods for improvement of understanding and use of content between methods.

A statistically significant difference was found only between time needed by participants to complete methods. The computer method took half an hour longer to administer than the paper method. One would think the computer methods should take less time; research indicated such possibility. Regardless, the resulting computer implementation took more time to complete. The computer method required extra time for familiarization and use. This time was believed to be problematic with difference between methods.

Future research seems warranted to investigate: time differences between methods, perception of individual differences in learning style, emphasis of main goals between the computer and the paper job-aids, and uniformity in scores on understanding and use of content. Perhaps such research can find evidence about why one method took more time, why one method allowed for user learning differences, how the computer emphasized main goals, and why scores tended to be uniform.

Already internet tools have shown great promise for uniformity of presentation, data exchange, instruction, and reporting. New object-based expert and knowledge development tools have been introduced. The trend is toward intuitive systems, expert systems, fuzz systems, knowledge-linking back to knowledge source and real time information. Developments may now provide live audio, near real-time video, intelligent objects, and more.

Recommendations

The purpose of this study was to develop a computer job-aid from a hard copy version, for industrial trainers using an object-based expert-system and to test the effectiveness of the resulting training process against the paper-based (hard copy) version. The expert knowledge-base had the requisite content and format for comparison through the computer method. After analysis, the computer method only exhibited an advantage in the perception of the respondents.

It is recommended that future efforts follow the wisdom overlooked by this research -- if a picture, an automatic method or a self prompting procedure will work, then test based training may be minimized. Better utilization of graphics is suggested along with video and audio to minimize choices. Standard screens are advisable. Such features may result in abbreviated computer models to reduce the administration time, and improve performance.

The methods used to implement the development of the computer job-aid could have seriously biased the study. Comments from the participants indicated a need for more brevity. Since the start of this study Expert Advisors have surfaced in application to law (OSHA computer based expert advisors). These have been question and answer systems with no explanation; just answer blocks. In these systems, texts may be available in the form of helps only. (The lack of helps was a criticism that surfaced in evaluation of the computer job-aid). In the OSHA Expert Advisor, calculations were provided by programmed questions with response blanks (formulas were previously Programmed) and unprogrammed responses. If a question and answer procedural system had been implemented, then the advisor could have calculated answers (returned automatically) and errors could have been eliminated or reduced. Such a system could return a high numerical score on posttest evaluation. Additionally, helps may then not be necessary. The knowledge-base did not provide adequate stand alone procedures and features. Automatic linking and retracing were common and appeared to cause confusion for the user. The impression derived from reaction of participants indicated that an abbreviated stand alone job-aid without extensive text could be desirable. Such a device may lead to the result without complete understanding or perhaps without any understanding of the topic. The users of the computer system seemed to expect less work on their part. Since this was a training development, the abbreviated version was excluded but should be included in any future work.

Perhaps the electronic accessibility of the document can be of greater value and does lend itself to meeting human perceptual needs. Further, this system was built with reuse in mind; from the electronic objects, inheritance is possible. This means that components of this program need not die but can pass along attributes to other future developments. The program components contain expert knowledge and may be reused in other development shells by referencing their file names. In this way future development on this topic can be built without the difficulty experienced in this research. This is evolutionary programming with real advantage worth continued study.

Self testing was part of the job-aid. The self check computer program needed to be improved to allow freedom of excursion. The users wanted to move freely without the knowledge that they were in an alternate environment. They liked multitasking but seemed to lose confidence if the program environment changed. Self testing tools (other than true/false and multiple choice) is difficult to find and when they are located they are custom proprietary systems. Future efforts should avoid the appearance of a change in operating environments and should investigate testing tools. There seems to be a great lack of fill in the blank and response type tools.

Briefly, one should use more graphics, less text, more automatic calculation blocks, and video and audio are suggested as beneficial. Automatic path features need to be in the control of the user always. The user needs to be able to return to the last location whenever the need arises. Self check testing needs to become part of the object environment. Last, the development environment must contain all the tools necessary for a completed product and that product should utilize drag and drop features with animation.

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Appendices

Appendix A

Complete training document:

Determining the Cost Effectiveness of Training

Human Resource Development Department The University of Tennessee

DETERMINING THE COST EFFECTIVENESS OF TRAINING

Learning Objectives

Upon successful completion of this module, you will be able to:

1. Determine when to measure and report the cost effectiveness of training
2. Calculate the costs of training
3. Describe four levels of measuring training effectiveness
4. Select the outcomes (benefits) to be measured and link training to those outcomes
5. Compute how much training returns relative to its cost (return on investment)
6. Justify training investments based on the cost-benefit ratio
7. Compute the value added by training, using the bottom-line evaluation method
8. Apply the payback period method to determine how long it will take for training to pay for itself
9. Describe the advantages and disadvantages of four different methods of determining cost effectiveness
10. Apply four methods to determine if a training program is cost effective

Rationale (purposes)

1. To discuss the need for justifying training expenditures with documented benefits
2. To provide details on (a) calculating training costs, (b) measuring the effectiveness of training, and (c) methods used in determining the cost effectiveness of training. These methods provide quantitative evidence that effective training is a worthwhile investment rather than a cost.

While this module focuses on the cost effectiveness of training by private sector organizations, the content is also applicable to training provided by public (government) employers.

<u>Introduction</u>

Due to intense competition in an era of rapid economic and technological change, employers are closely scrutinizing their spending on workforce training. Increasingly, training departments and human resource professionals are being asked to justify whether training is a worthwhile investment. Training managers would prefer to measure the effectiveness of their courses and programs with data from criterion-referenced tests and feedback questionnaires. However, higher management requires that training be further justified in terms that are important to them (financial).

<u>Organization of the module.</u> This module is organized in three parts. The first part points out why some training managers are reluctant to determine the cost effectiveness of training. It discusses the need to justify training expenditures with documented benefits. Part 1 also provides practical details and examples of how to calculate the direct, indirect, and full costs of training. A progress check is provided to facilitate your understanding of the content covered and to promote learning.

Part 2 describes four levels of measurement used to determine the effectiveness of training. In addition, the need for a cause-and-effect link between a specific organizational problem and a performance deficiency is addressed. This second part of the module also discusses the selection of outcomes (benefits) to be baselined before training and tracked after training in order to determine the payback. Like Part 1, there is a progress check to facilitate review of the content covered in order to promote learning.

Part 3 of the module presents four methods for determining the cost effectiveness of training courses and programs. The methods described are:

1. Return on investment (ROI)
2. Cost-benefit ratio
3. Bottom-line evaluation
4. Payback period

In addition to providing details and examples for each of these methods, their advantages and disadvantages are identified and listed in a table. Furthermore, a progress check is provided for each method. These progress checks will help you determine how well you understand each method.

At the end of the module is a practical example to facilitate a skill check on your understanding and attainment of the learning objectives listed on page 1.

A note on terminology. In order to enhance understanding, some definitions of the terminology used in this module require clarification.

- **Bottom-line evaluation.** This method shows the value added to each trainee's job performance and the total value added to an organization from training.
- **Cost-benefit ratio.** The ratio of projected costs of training to its estimated benefits. It is a useful method for justifying training investments when the benefits attributable to training are difficult to quantify in monetary units.
- **Cost effectiveness.** The results attained against the costs of time, effort, money, and inconvenience. Cost effectiveness also suggests assigning quantitative values to performance improvements. The criteria for effectiveness are value, worth, and merit.
- **Payback period.** A method for initial consideration of a questionable training investment. It answers the question, "How long will it take the training to pay for itself?".
- **Return on investment (ROI).** The rate of what something returns relative to its cost. It is a calculative approach to evaluating a result against the amount of resources invested.

Part 1 — Training Costs

When to Measure Cost Effectiveness

Employers have traditionally supported training because (a) it shows the organization's concern for its employees, and (b) higher management "assumes" that the benefits exceed the costs. In any event, when higher management "believes" that training is operationally critical to the organization's competitive position, there may be little or no demand for cost-effectiveness information.

Therefore, despite the increasing admonishment found in training literature about the importance of demonstrating that training is a worthwhile investment, many training managers routinely avoid the use of economic justification. However, when a belief in the value, worth, and merit of training is not part of an underlying business philosophy, reporting the cost effectiveness of training can help the training manager establish credibility and may enhance the organization's willingness to invest additional resources.

The single greatest incentive for indicating the cost effectiveness of training is its use in **justifying training expenditures with documented benefits.** Uncertainty about continued support for the training function leads to the consideration of cost-effectiveness information as a defensive measure — a way of showing higher management that training is not a luxury. Consequently, a growing number of training managers have a desire to **show a return on training investments similar to that on other business investments.** Nevertheless, many lack the knowledge necessary to determine the costs and benefits of training courses and programs (Lombardo, 1989).

When asked to report on a training investment, training managers often hesitate to calculate the costs necessary to develop, deliver, and evaluate training, and are reluctant to document and report the benefits such as increased quality, productivity, sales, and so forth. Among the reasons cited for this reluctance are the

1. Lack of reliable cost figures
2. Difficulty in identifying, monitoring, and quantifying training benefits
3. Subjective nature of the assumptions to be made

4. Inability to isolate training's influence on performance improvements from other factors

5. Time and effort involved in calculating the costs and documenting the benefits of training

6. Potential for unfavorable returns on the investment

Notwithstanding these and other reasons, training managers who feel the need to justify training with evidence that the benefits exceed costs will welcome the opportunity to determine the cost effectiveness of training using the methods presented in this module. These methods can provide quantitative evidence that effective training is a worthwhile investment rather than a cost. Once in place, the methods become easier to use each time they are applied.

Calculating the Costs of Training

Costs are incurred in developing, conducting (delivering), and evaluating training. These **costs are categorized as direct and indirect.** The **full cost of training** is the sum of all direct and indirect costs.

Often, the training manager will not have access to many of the direct and indirect costs of training and must obtain figures or reliable estimates from the organization's payroll, budget, accounting, or comptroller's office. Usually, however, all costs can be accounted for.

Direct costs. Direct costs are expenses tied specifically to a product (training course or program) (Usry, Hammer, & Matz, 1988, p. 26). **Direct personnel costs** include the wages and benefits paid to or on behalf of employees involved in training (e.g., trainees and instructors) as well as fees paid for professional services purchased from external providers (contractors, consultants, etc.). Also included in direct costs are training development and instructional materials preparation (including production) costs, or the review of materials purchased from a vendor. Other direct costs are materials and supplies, equipment, facilities, and travel and per diem.

Organizations generally pay all employee/trainee costs. Training is typically conducted during working hours; consequently, trainees are not available to perform their regular jobs. As a result, every hour which the trainee spends in training costs the organization the equivalent of an hour's wages and benefits for that employee (Deming, 1982).

In calculating personnel costs, **wages and benefits need to be taken as a total compensation package.** All employer-paid benefits, such as insurance, pensions, time paid but not worked (vacation, holidays, sick leave, etc.), and other contributions are included. In the United States, these employer-paid "fringe" benefits average 35% of direct salary costs (Carnevale & Schulz, 1990). A calculation of total daily compensation package costs is shown below.

EXAMPLE OF A TOTAL COMPENSATION PACKAGE

The hourly wage for a welder is $17. In addition, the fringe benefits package costs the employer an additional 30%. The employer's cost for a welder's total daily (8-hour) compensation package is

$17	x	8 hours	+	30 %	x	($17 x 8)	=	$176.80
Hourly wage		Hours per day		Fringe benefits percent		Daily wage		Total daily compensation package

[. . . Daily wage . . .]

Additionally, employees' time is worth more than their total compensation package because they are expected to contribute to the organization's profitability. Consequently, there can be a cost of disruption to productivity or a loss of productivity during training time. This cost becomes more apparent as the number of employees away from their job and the length of training increases. Nevertheless, the total compensation package is the generally accepted means for calculating trainee costs.

EXAMPLE OF TRAINEE COSTS

Ten welders are attending a two-day workshop on welding techniques. Each welder has a total daily compensation package, including fringe benefits, of $176.80. The trainee costs associated with their participation in this workshop are

10	x	2 days	x	$176.80	=	$3,536.00
Number of trainees		Length of training		Total daily compensation package		Trainee costs

Just as trainee costs are calculated as a direct personnel cost, so should instructor costs be. Yet, more may be involved than just the days the instructor commits to delivering training. In addition, preparation time should be added (Deming, 1982).

EXAMPLE OF INSTRUCTOR COSTS

An instructor requires 1 day of preparation time for a two-day workshop. The instructor's total daily compensation package is $200. The instructor costs associated with this workshop are

1	x	(2 days	+	1 day)	x	$200	=	$600
Number of instructors		Length of training		Length of preparation		Total daily compensation package		Instructor costs

If an organization contracts for **external training services**, the costs of developing and delivering the training as well as the cost of preparing/producing instructional materials may be lumped together with all other costs the contractor or consultant charges. However, when the training is developed internally, **training development and instructional materials preparation costs** need to be calculated.

Calculation of training development and instructional materials preparation costs can be made based on the time expended by the developer(s) and instructional materials production personnel involved, and on the costs of materials and supplies required in preparing all types of instructional materials, including printed materials, audiovisual media, manipulative aids, etc. A calculation of development and materials preparation costs could look like the following example (Deming, 1982).

EXAMPLE OF TRAINING DEVELOPMENT AND INSTRUCTIONAL MATERIALS PREPARATION COSTS

A developer spends 4 days developing a training workshop and an additional 7 days preparing printed instructional materials. No production personnel are involved. The developer's total daily compensation package is $225. The cost of materials and supplies required in preparing the instructional materials is $250. The training development and instructional materials preparation costs associated with this workshop are

1	x	(4 days	+	7 days)	x	$225	+	$250	=	$2,725
Number of developers		Days for training development		Days for materials preparation		Total daily compensation package		Cost of materials and supplies		Development and preparation costs

Training development and instructional materials preparation costs can be treated differently than trainee and instructor costs insofar as the training will be repeated. For example, if the cost of developing the training and preparing instructional materials was $2,725 and the workshop was conducted 10 times, then the development and preparation cost assigned to any one workshop would be the total cost ($2,725) divided by the number of workshops (10), or $272.50 per workshop (Deming, 1982).

Another way to treat training development and instructional materials preparation costs is to amortize them over the number of trainees. For example, if the development and preparation cost was

$2,725 and a total of 150 welders were trained in the 10 workshops, then the cost per trainee would be the total cost ($2,725) divided by the number of trainees (150), or about $18.17 per trainee. These simple calculations show that (a) the more times the training is delivered, and (b) the more welders trained, the more economical the investment in training development and instructional materials preparation will be.

Training managers may purchase "off-the-shelf" instructional materials marketed by a vendor. The purchase price of instructional materials such as books, modules, video tapes, etc., as well as consumable supplies, like pencils, paper, binders, and chalk, can be grouped under the heading, **instructional materials costs** (Deming, 1982).

Some instructional materials costs are the result of multiplying a per-trainee cost by the number of trainees. For example, if 10 trainees each receive a purchased $30 book, the cumulative total cost is $30 multiplied by 10 trainees, or $300.

EXAMPLE OF INSTRUCTIONAL MATERIALS COSTS

The instructional materials for a welding workshop include books purchased from a vendor, costing a total of $300, and consumable supplies which cost $75. The instructional materials costs associated with this workshop are

$300	+	$75	=	$375
Purchased instructional materials		Consumable supplies		Instructional materials costs

Training involves **equipment costs** when machines are essential to effective instruction and learning. Under certain conditions, equipment must be rented or purchased and then maintained. In other instances, training can be scheduled to use equipment available in the organization. For example, welder training requires the use of a gas tungsten arc pipe welding machine. The machine's usage for training may, for all practical purposes, be cost-free if the training can be scheduled when the machine is idle. More than likely, however, training workshops would be conducted during normal working hours and the existing pipe welding machine could not be diverted from production for training purposes. Consequently, a duplicate machine would have to be rented or purchased, and maintained.

EXAMPLE OF RENTED EQUIPMENT COSTS

The cost of renting a pipe welding machine for a two-day workshop is $150 per day. In addition, maintenance costs for the machine are $10 per day. The equipment costs associated with this workshop are

2 days	x	($150	+	$10)	=	$320
Length of training		Equipment rental per day		Maintenance cost per day		Rental and maintenance costs of equipment

When equipment is purchased specifically for training, its purchase price can be amortized (written off) over the item's useful life, with yearly maintenance costs added, to find the annual cost. The annual cost is then distributed evenly to all training courses and programs in which the item is used. An example of how to calculate the annual cost and cost per workshop for an item of purchased equipment is provided on the following page.

EXAMPLE OF PURCHASED EQUIPMENT COSTS

A pipe welding machine was purchased exclusively for training. It cost $24,000 and has an estimated useful life of 5 years. The machine has a yearly maintenance cost of $1,800, and it will be used for 10 workshops per year. The annual equipment cost and cost to each workshop for this machine can be calculated as follows.

($24,000	÷	5 years)	+	$1,800	=	$6,600
Purchase price of equipment		Useful life of equipment		Maintenance cost per year		Annual equipment cost

$6,600	÷	10	=	$660
Annual equipment cost		Number of workshops		Equipment cost per workshop

If a workshop uses several pieces of rented or purchased equipment, their costs are added together (Carnevale & Schulz, 1990).

Facilities costs are incurred when a training facility is built, shared, or rented. In cases where a building or special structure is built for training use, the cost can be amortized over its functional life, with yearly maintenance costs added (as in the purchase of equipment).

Whenever training is conducted within a facility that is used for other organizational functions as well, the appropriate fraction of that facility's cost ought to be billed to training (Deming, 1982).

EXAMPLE OF FACILITIES COSTS (sharing a facility)

Organization facilities which are used 10% of the time for training have a yearly cost, including maintenance and building administration, of $18,000. The annual facilities costs associated with the training use of these facilities are

$18,000	x	10 %	=	$1,800
Yearly cost of facilities, including maintenance and building administration		Percent of time used for training		Annual facilities costs for training

When organization facilities are used only occasionally for training, a daily rate method may be preferable over the percent of use method shown above. To calculate the daily facilities rate, the total annual facilities cost (for all functions) is divided by the number of working days in the year. If the organization in the above example operates 5 days per week, 52 weeks per year (260 days per year), then their daily facilities rate would be $18,000 divided by 260 days, or about $69.23. The daily rate is then multiplied by the number of days the facility is used for training. For example, the facilities cost for a 2-day workshop would be $69.23 multiplied by 2 days, or $138.46. The percent of use method may then be applied to the result, if appropriate.

In those instances when the **rent** for a shop, classroom, seminar room, etc. is not a flat fee, total facilities costs for a given workshop are computed by multiplying the daily rental rate by the number of rental days. For example, the total facilities costs for a 2-day welding workshop held in a vocational training center that charges $200 per day for its welding shop would be $200 multiplied by 2 days, or $400.

For on-site training, **travel and per diem costs** are likely to be of little consequence. But for training away from the workplace, they are serious cost factors.

EXAMPLE OF TRAVEL AND PER DIEM COSTS

Ten welders traveled to another city for a 2-day workshop. Their employer is paying the $300 airfare and $70 daily per diem to cover meals, lodging, and other living expenses for each trainee. The employer's costs for travel and per diem for the trainees are

(10	x	2 days	x	$70)	+	(10	x	$300)	=	$4,400
Number of trainees		Length of training		Daily per diem rate		Number of trainees		Round-trip air fare		Travel and per diem costs

<u>Indirect costs.</u> Indirect costs are expenses which cannot be traced back to a specific training course or program, but which are necessary for an organization to function. Although indirect costs for training are less visible than direct costs, they are substantial.

Examples of indirect costs include interest on organizational debt, building repairs, utilities, organizational supplies and equipment, administrative and staff support salaries, and expenses for legal, payroll, accounting, and other personnel. Organizations often subdivide such costs into **overhead** and **general and administrative (G & A)** expenses (Carnevale & Schulz, 1990). Overhead and G & A expenses are generally obtained from the organization's accounting office because they are arrived at through allocation, sometimes on a judgmental basis.

<u>Full cost of training.</u> The final calculation to obtain the full cost of a training course or program is a simple addition problem. **First, direct costs** tied to a course or program **are summed**, including

1. Total compensation packages for employees involved in training (e.g., trainees and instructors)

2. Fees for external training services (contractors, consultants, etc.)

3. Training development and instructional materials preparation costs

4. Costs of instructional materials and consumable supplies purchased from a vendor

5. Equipment costs

6. Facilities costs

7. Travel and per diem costs

Second, indirect costs are summed, e.g., overhead and G & A costs. Finally, the totals from the direct and indirect costs are summed to obtain a grand total, the full cost of training.

EXAMPLE OF A FULL COST OF TRAINING CALCULATION

Total direct costs for a 2-day workshop are $10,000. Total indirect costs consist of allocated overhead of $1,560 and allocated G & A expenses of $375. The full cost of training is

$10,000	+	($1,560 + $375)	=	$11,935
Total direct costs		Total indirect costs		Full cost of training

__Conclusion.__ While calculating the full cost of training is a first and critical step in determining cost effectiveness, monitoring costs is also important to planning and controlling the training budget. In addition, by analyzing costs, training managers are better able to evaluate the proportion of the organization's investment in specific training populations (supervisors; production, maintenance, or office workers; etc.), a particular program, course, or topic, and so forth.

This part of the module shows that a training manager can calculate the costs of training, albeit with the help of those who have access to fiscal data. More challenging is the art of collecting evidence of favorable training outcomes, but it too can be done, as the next part of the module shows.

Progress Check -- Part 1 – Training Costs

Directions. Read each of the following items carefully and write in your answer. If you have difficulty with any of the 13 items, go back and review the relevant content before continuing. Use a calculator or another sheet of paper for your calculations. Check your answers against those provided in the Progress Check Feedback at the end of this module.

1. Identify the greatest incentive for indicating the cost effectiveness of training.

   ____

2. Name two categories of training costs.

   (1) ______________________________

   (2) ______________________________

3. Calculate the total daily (8-hour) compensation package for an employee whose hourly wage is $16, and whose fringe benefits package costs his employer an additional 29%.

   Total daily compensation package = ______________

4. Calculate the training costs for 12 trainees, with individual total compensation packages of $195 per day, who attend a 5-day training program.

   Total trainee costs = ______________

5. Calculate the instructor costs for a 5-day workshop with one instructor who requires 2 additional days for preparation. The instructor's direct salary is $180 per day, with a 30% fringe benefits package.

   Total instructor costs = ______________

6. Calculate the training development and instructional materials preparation costs for two developers, with a total daily compensation package cost to the organization of $220 each, who worked 5 days on developing training and 8 days on preparing instructional materials. The cost of supplies used in preparing the instructional materials was $210.

   Total development and preparation costs = ______________

Progress Check (continued)

7. The cost of developing training and preparing printed instructional materials for a 5-day seminar was $6,300.
   A. What will be the cost per seminar if it is offered once each month for one year?
   Cost per seminar = ____________________
   B. If the seminar is offered only twice, to a total of 30 trainees (15 in each session), what will be the cost per trainee?
   Cost per trainee = ____________________
8. The employer purchased books and modules for each of 12 trainees, costing a total of $180 per trainee. Paper and pencils, which cost $45 total, were also required. Calculate the total cost of these instructional materials.
   Total instructional materials costs = ____________________
9. Welding Associates rented equipment for a 4-day training program (workshop) they are conducting. The rental cost for the equipment is $300 per day. Maintenance costs associated with the equipment are $20 per day. What will be the equipment costs for this training program?
   Equipment costs = ____________________
10. Welding Associates is considering purchasing the arc welding machine needed for training. The machine's purchase price is $22,500 and its estimated useful life is 5 years. In addition, yearly maintenance costs for the purchased machine are expected to be $2,100.
   A. What will be the total annual cost of the machine?
   Total annual equipment cost = ____________________
   B. If Welding Associates uses the machine in a training program offered 12 times per year, what will be the equipment cost for each program?
   Equipment cost per training program = ____________________

Progress Check (continued)

11. Welding Associates estimated their total facilities costs, including maintenance, for the current year to be $40,000.
    A. If the facilities are used 15% of the time for training, what portion of the facilities costs should be allocated to the training budget?
    Facilities costs (for training) = ____________
    B. If the facilities are used for training 5 days per week, 48 weeks per year (240 days per year), what is the daily facilities rate for the use of these facilities?
    Daily facilities rate = ____________
12. Six welders will travel from their home to another city to attend a 3-day workshop where they will learn to use specialized equipment. Welding Associates agreed to pay each employee's $400 airfare plus $75 per day for other expenses. Calculate the travel and per diem costs incurred by Welding Associates for this 3-day workshop.
    Travel and per diem costs = ____________
13. Welding Associates found their total direct costs for a training program to be $17,000. Indirect costs, consisting of allocated overhead and G & A expenses, totalled $2,000. What was Welding Associates' full cost of training?
    Full cost of training = ____________

Part 2 – Training Effectiveness

<u>**Measuring the Effectiveness of Training**</u>

Donald Kirkpatrick organized the measurement of training effectiveness (value, worth, and merit) into four levels. These levels are listed below, from the easiest to measure (level 1) to the most difficult (level 4). In general, the more levels used to measure a training course or program, the more complete is the evidence of its effectiveness.

- Level 1 -- Measurement of trainees' reactions to the training (feedback)
- Level 2 -- Measurement of knowledge and skills acquired
- Level 3 -- Measurement of trainees' use of their new knowledge and skills on the job
- Level 4 -- Measurement of the organization's return on the training investment

Level 1 information is gathered most often with questionnaires handed out at the end of a course or program or sent to trainees a short time later. At level 2, criterion-referenced tests are used to measure the knowledge and skills acquired. Level 3 ascertains if trainees are applying the newly-acquired knowledge and skills back on the job.

Level 4 determines what benefits (increased quality, productivity, sales, etc.) the new knowledge and skills have had on the organization's performance, and their worth in monetary value. At level 4, training managers are asking about the organization's payback (return) on its training investment (Gordon, 1991).

In most cases, it is possible and feasible to link training outcomes to organizational improvements. Doing so does not require absolute isolation of training's benefits from the possible contributions of other variables. Rather, it requires evidence that demonstrates training's valuable role (Carnevale & Schulz, 1990). Consequently, arguments about whether a training manager can absolutely separate training's influence on organizational improvements and isolate the impact are not pertinent.

Indisputable proof is difficult to come by, even when a carefully designed study using experimental and control groups is conducted. However, evidence can be collected to show that training was at least a major contributor to a particular operational savings or increase in revenue. Kirkpatrick adds that evidence is all anybody really wants, anyhow. " . . . Management isn't going to ask, 'Can you prove it?' They'll ask for evidence. And evidence is not all that hard to come by" (Gordon, 1991, p. 23).

The key to collecting evidence of training outcomes is to establish a "causal link" between a specific organizational problem, preferably one to which monetary value can be assigned, and a performance deficiency. This is best done up front, before a training course or program is even developed.

Rejected workpieces in a manufacturing environment provide one example of an organizational problem. How much does the current reject rate cost the organization? Are rejected workpieces the result of a workforce skill deficiency, as opposed to inferior materials or equipment malfunctions? If so, there is a causal link.

After establishing the link between rejected workpieces and a skill deficiency, current reject costs are determined. The accounting office can provide figures for the cost of the materials used in manufacturing the workpiece. When this cost is added to personnel, equipment, and other appropriate manufacturing costs, the total cost of the rejected workpieces can be calculated. If the number of rejected workpieces declines after the workers are trained, the operational saving provides convincing, quantitative evidence that the training provided a return on the investment.

<u>Benefits.</u> By selecting the outcomes (benefits) to be measured and linking training to those outcomes while holding, to the extent possible, other factors constant, level 4 measurement becomes a relatively simple matter. All training managers have to do is track the outcomes for which baseline measures were gathered before the training, and they will know what the payoff is. Among the most important outcomes (benefits) to be documented are (a) increased quality, productivity, sales, service, safety, and workforce flexibility; (b) reduced operational costs, medical insurance and

workers' compensation claims; and (c) lower absenteeism. Other outcomes, which are more difficult to document and quantify, include the increased stability of the workforce; improved morale, harmony, job satisfaction, and attitude; a lower requirement for supervision; the formation of selection pools for promotion; supervisory skill development; and improved customer relations.

Conclusion. Once training managers learn how to calculate the cost and measure the effectiveness of training, they can begin to describe the benefits from a financial perspective. **Is the training effort producing benefits that are greater than the costs involved? This, ultimately, is what higher management wants to know.**

A variety of methods are available for determining the cost effectiveness of training. Some are complex and cumbersome to use, while others are more suitable for justifying an investment in a new machine for a manufacturing plant, a new way of doing a job, and so forth. The four methods for justifying a training investment presented in Part 3 of this module were selected because they are (a) practical, (b) relatively easy to use, and (c) generally familiar to higher management. It must be pointed out, however, that all four methods have disadvantages. Consequently, none of them should be regarded as a precision tool. Nevertheless, these methods are based on accepted principles and present organized state-of-the-art procedures for determining the cost effectiveness of training courses and programs.

Progress Check -- Part 2 – Training Effectiveness

Directions. Read each of the following items carefully and write in your answer. If you have difficulty with any of the items, go back and review the relevant content before continuing. Check your answers against those provided in the Progress Check Feedback at the end of this module.

1. Kirkpatrick noted that the effectiveness of training can be measured at four different levels. Briefly describe the levels.

   (1) ______________________________

   ____

   (2) ______________________________

   ____

   (3) ______________________________

   ____

   (4) ______________________________

   ____

2. Is it possible and/or feasible to link training outcomes to organizational improvements without the absolute isolation of training's benefits from the possible contributions of other variables?

   _______ Yes, it is both possible and feasible.

   _______ It is possible, but not feasible.

   _______ It is feasible, but not possible.

   _______ No, it is neither possible nor feasible.

3. What is the key to collecting evidence of training outcomes?

   ____

   ____

   ____

4. Identify the result of selecting the outcomes to be measured and linking training to those outcomes.

   ____

Part 3 — Methods Used to Determine the Cost Effectiveness of Training

Return on Investment (ROI)

ROI is the rate at which training returns what was invested (its cost). It is an indicator of a particular course or program's value, worth, and merit. Of the four methods for determining the cost effectiveness of training presented in this module, the ROI method is probably the most appealing to higher management, since managers are accustomed to thinking in terms of return on investment. However, the ROI method is appropriate only when it is possible to quantify outcomes (benefits) in monetary units (Kearsley, 1982, p. 92).

The following steps must be taken before a ROI report can be prepared:

- Step 1 -- Calculate the direct and indirect costs associated with the training course or program. These costs are then summed to obtain the full cost of training. (See Part 1 of this module for details.)
- Step 2 -- Gather baseline measures for those outcomes to be analyzed in step 3, **before training occurs.** This is the only way to know what changes took place.
- Step 3 -- Analyze the effects of training on the outcomes (benefits), such as increased quality, productivity, sales, service, safety, and workforce flexibility; reduced operational costs, medical insurance and workers' compensation claims; and lower absenteeism; or any other measurable benefit. In order to apply the ROI method, these benefits must be quantified in monetary units.

Once the full cost of training is calculated, and the outcomes have been analyzed, the ROI can be computed. **Training managers should analyze only those outcomes that are accomplished, at least in part, by training.** To create a credible ROI report, training managers must present evidence that is important and believable to higher management.

Two common approaches for expressing the ROI for a training course or program are to consider **operational savings** and **increases in revenue.** For example, the training manager can assess whether an operational cost, such as accidents due to human error, is significantly lower after employees master safety procedures. In this case, the ROI is the rate at which training costs are recovered by a reduction in the number or severity of accidents.

Reductions in accidents positively affect revenue, through lowered health care costs, insurance premiums, and disability claims, and increase productivity through fewer absentee days. Higher management will be impressed with evidence of training's valuable role in achieving both operational savings and increases in revenue. Consequently, they will look more favorably on training as a value-added service instead of just a "nice to have," but dispensable, cost of operation.

To calculate a ROI, total operational savings and increases in revenue resulting from the training are divided by the full cost of training. ROI expressed as a formula is

$$\frac{\text{Operational savings + increases in revenue}}{\text{Full cost of training}} = \text{ROI}$$

Obviously, any training for which the ROI is greater than one (1.0), the break-even point, is worthwhile, because the benefit derived from the training is greater than its cost (we are "getting out" more than we "put in"). However, a ROI of less than 1.0 means that the training investment was greater than the return.

EXAMPLE OF ROI

A safety training program resulted in operational savings through a $35,000 reduction in accident costs/payments the first year. There was also an annual increase in revenue of $5,000 as a result of fewer absentee days. The full cost of training was $25,000. The program's ROI was

$$\frac{\$35{,}000 + \$5{,}000}{\$25{,}000} = 1.60 \text{ (or 160\%)}$$

This training program was a worthwhile investment. It returned 160% – the original $25,000 training cost plus an additional $15,000 (60%) in the first year. It will no doubt continue to provide a benefit, even without an additional training investment.

Advantages of the ROI method.

- Provides an indicator of the training's value, worth, and merit.
- Easily understood by higher management.
- Management will be impressed with a favorable ROI report and will view training as a value-added service.

Disadvantages of the ROI method.

- It is appropriate only when it is possible to quantify outcomes (benefits) in monetary units.
- Baseline measures must be gathered for outcomes before training occurs.
- Evidence of operational savings and increases in revenue is available only after the training is conducted. Therefore, its application in predicting a favorable return is limited.

Note. The advantages and disadvantages of the ROI method can be easily compared with those of the cost-benefit ratio, bottom-line evaluation, and payback period methods by referring to Table 1 on pages 40 and 41.

Progress Check -- Return on Investment (ROI)

Directions. Read each of the following items carefully and write in your answer. If you have difficulty with any of the items, go back and review the relevant content before continuing. Use a calculator or another sheet of paper for your calculations. Check your answers against those provided in the Progress Check Feedback at the end of this module.

1. A technical training program is saving your organization $20,000 per year and has increased revenue by $26,000 per year. The full cost of training was $40,000.

   A. What was the ROI of this training investment?

   ROI = ______________________________

   B. Was this a worthwhile investment?

   Yes _______ No _______

   Why or why not?

   ____
   ____
   ____
   ____
   ____
   ____

   C. Would your opinion change if you could have invested the $40,000 in a savings fund at a guaranteed 17% annual return instead?

   Yes _______ No _______

   Why or why not?

   ____
   ____
   ____
   ____

Cost-Benefit Ratio

The cost-benefit analysis (ratio) method is used to determine the ratio of the **projected full cost** of a given course or program to its **predicted benefits**. This method is especially suitable for justifying training investments when the benefits attributable to training are difficult to quantify in monetary units.

The cost-benefit ratio formula is presented below:

$$\frac{\text{Projected full cost of training}}{\text{Predicted training benefits}} = \text{Cost-benefit ratio}$$

If the cost-benefit ratio is less than one (1.0), the training would be worthwhile, because its predicted benefits exceed its projected costs. The smaller the ratio, the stronger the justification for training. If the ratio is greater than 1.0, costs exceed benefits and the training may not be justifiable, except when mandated by law (compliance training).

The benefits of many courses and programs, such as supervisory skill development, are not easy to show or quantify. Benefits such as reduced workforce turnover, as well as improved morale, harmony, job satisfaction, and attitude are hard to quantify in monetary units, yet they should not be overlooked. No matter how difficult it may seem to put a value on employee turnover, for example, an effort must be made to quantify all benefits for this method to work.

Technically precise and entirely objective monetary information simply is not available on the benefits for some "soft-skills" training. However, the following practical procedure provides appropriate figures for benefits that are difficult to quantify.

Before training is developed and delivered, line managers are asked to estimate the annual operational savings they expect to result for their department. These managers also rate their level of confidence, on a 0 to 100% scale, that the training will be responsible for the savings. **Estimated operational savings are then multiplied by the "confidence" percentage to yield a prediction of total cost savings** (benefits) from training.

EXAMPLE OF COST-BENEFIT RATIO

A company is considering supervisory skills training for its foremen. The enhancement of supervisory skills is expected to reduce workforce turnover. Line managers have been asked to estimate the annual operational savings they expect as a result of the reduced turnover and to rate their level of confidence that training will be responsible for the savings. They estimated the operational savings (from the reduced turnover) at $100,000, with a confidence rating of 50%. The full cost of the potential training program is projected to be $10,000. The expected cost-benefit ratio of this training investment is

$$\frac{\$10,000}{\$100,000 \times 50\ \%} = 0.20$$

Because the cost-benefit ratio is less than 1.0, the training program is considered worthwhile.

Although this example is brief, it illustrates the principles and procedures of the cost-benefit ratio method in providing evidence that this soft-skills course is worthwhile.

Advantages of the cost-benefit ratio method.

- Especially suitable in training situations where the benefits are difficult to quantify in monetary units.
- Practical procedure that provides appropriate figures for benefits that are difficult to quantify.
- Shows whether training is worthwhile, before the course or program is developed and delivered.

Disadvantage of the cost-benefit ratio method.

- The procedure used to predict training benefits in monetary units is subjective.

Note. The advantages and disadvantages of the cost-benefit ratio method can be easily compared with those of the ROI, bottom-line evaluation, and payback period methods by referring to Table 1 on pages 40 and 41.

Progress Check -- Cost-Benefit Ratio

Directions. Read each of the following items carefully and write in your answer. If you have difficulty with either item, go back and review the relevant content before continuing. Use a calculator or another sheet of paper for your calculations. Check your answers against those provided in the Progress Check Feedback at the end of this module.

1. Mr. Whiz predicted that a computer technician training program for two of his employees would result in a total cost savings of $9,000 per year in computer repairs and down-time. He rates his level of confidence, that the training will be responsible for this savings, at 80%. The projected full cost of the technician training is $2,000 per person.

   A. Calculate the cost-benefit ratio for this potential training investment.

      Cost-benefit ratio =

      ____

   B. Do you think this training would be a worthwhile investment for Mr. Whiz's company?

      Yes _______ No _______

      Why or why not?

      ____

      ____

Bottom-line Evaluation

The bottom-line evaluation method presented here determines the value added by training to each trainee's productivity, and the total value added to the organization by the training course or program. The total value added to the organization is compared to the full cost of training to determine if the training was a worthwhile investment.

This method incorporates two of Kirkpatrick's four levels of measuring the effectiveness of training. (See Part 2 of this module for a description of all four levels.) It collects both level 4 (measurement of the organization's return on the training investment) and level 1 (measurement of trainees' reactions to the training) data at the same time. A questionnaire is developed to collect level 4 and level 1 data from trainees after they have applied, back on the job, what they learned in the training.

Trainees indicate their individual opinions of (a) percent of job-time spent performing the task trained (T), (b) pre-training productivity percentages (P1), and (c) post-training productivity percentages (P2). Along with questionnaire responses, other information necessary to perform a bottom-line evaluation includes a list of the tasks performed by the trainees and their total annual compensation package (S). The bottom-line evaluation method expressed as a formula is

$$(S \times T) \times (P2 - P1) = \text{Value added by training}$$

(S	x	T)	x	(P2 - P1)	=	Value added by training
Total annual compensation package		Percent of job-time spent performing task trained		Percentage change in productivity as a result of training		

[Annual per-task compensation]

The bottom-line evaluation method promotes the use of job analysis information in that tasks performed by the employee/trainee must be identified, along with percent of job-time spent on those tasks, in order to calculate per-task compensation (S x T, in the above formula).

Criticisms of the bottom-line evaluation method include: (a) trainee questionnaire responses are subjective perceptions; and (b) potential for biased questionnaire input. However, the calculated value added can be corrected for bias using statistical methods.

Despite the criticisms, however, this method does promote employee participation in decision making. Employees often feel that they are the best judges of their individual performance improvement following training. The method also appeals to management because it links employees' job task performance with their productivity, by comparing the full cost of the training with the value the organization receives from it.

EXAMPLE OF BOTTOM-LINE EVALUATION

A training program in erecting and dismantling scaffolding was provided to three employees. After the employees returned to their job and applied the knowledge and skill acquired, they were asked to complete a questionnaire. Each employee supplied information on their perceptions of (a) percent of job-time spent performing the task trained, and (b) pre- and post-training productivity percentages. Each employee's total compensation package, percent of job-time spent performing the task trained, and pre- and post-training productivity percentages are presented in the table below, along with their individual and total value added to the organization as a result of the training.

Employee/ trainee	Total annual compensation package ($) [S]	Job-time (%) spent performing the task trained [T]	Component pay ($) [D = SxT]	Pre-training productivity (%) [P1]	Post-training productivity (%) [P2]	Productivity gain (%) [G = P2-P1]	Value added ($) [GxD]
1	$29,000	25%	$7,250	30%	80%	50%	$3,625
2	$30,000	20%	$6,000	40%	90%	50%	$3,000
3	$34,000	15%	$5,100	50%	80%	30%	$1,530
Total value added							$8,155

The total value added to the organization by the training program was $8,155. If the full cost of training was less than $8,155, then the training program was a worthwhile investment.

Advantages of the bottom-line evaluation method.

- Promotes the use of job analysis information.
- Promotes employee participation in decision-making.
- Appeals to management, because it links job task performance with training and productivity.
- Allows the total value added to the organization to be compared to the full cost of training to determine if the training was a worthwhile investment.

Disadvantages of the bottom-line evaluation method.

- Questionnaire responses are subjective perceptions by trainees.
- Questionnaire data collected might be biased.

Note. The advantages and disadvantages of the bottom-line evaluation method can be easily compared with those of the ROI, cost-benefit ratio, and payback period methods by consulting Table 1 on pages 40 and 41.

<u>Progress Check -- Bottom-Line Evaluation</u>

<u>Directions.</u> Read each of the following items carefully and write in your answer. If you have difficulty with any of the items, go back and review the relevant content before continuing. Use a calculator or another sheet of paper for your calculations. Check your answers against those provided in the Progress Check Feedback at the end of this module.

1. A training manager has identified all the tasks performed by each employee within the organization, along with their total compensation packages. The training department is providing a welding training program for the welding department's four employees, at a total cost of $4,400. Each welder has a total annual compensation package of $20,000. The training manager would like to present training's value to higher management. The training is delivered and questionnaire results, in table form, are as follows.

Employee/ trainee	Total annual compensation package ($) [S]	Job-time (%) spent performing the task trained [T]	Component pay ($) [D = SxT]	Pre-training productivity (%) [P1]	Post-training productivity (%) [P2]	Productivity gain (%) [G = P2-P1]	Value added ($) [GxD]
1		10%		20%	60%		
2		40%		20%	50%		
3		30%		30%	50%		
4		20%		40%	60%		
Total value added							

A. Complete the table. For each employee, you will need to calculate component pay, productivity gain, and value added. You will also need to calculate the training program's total value added to the organization.

Progress Check (continued)

B. Was the training program worthwhile?

Yes ________ No ________

Why or why not?

____

____

Payback Period

The fourth method of determining the cost effectiveness of a training investment is called the payback period method. This **forecasting** method answers the question, "How long will it take the training to pay for itself?" **This method should,** however, **be used only as an initial look at a questionable training investment.**

The payback period method does not consider the cost or time value of the money spent and tied up before, during, and after the training until the break-even point is reached. Nevertheless, it does consider some time factors in calculating the payback.

If the payback period is very short, less than one year, for example, then the training course or program is definitely promising and another method, such as ROI, cost-benefit ratio, or bottom-line evaluation, should be used for a closer examination of the training's value, worth, and merit to the organization. If the payback period is very long, 10 years, for example, then there may be no need to consider the training further, depending on the organization's philosophy about the maximum length of time allowed for investment resources to be returned.

The payback period method is represented by the following formula:

$$\frac{\text{Full cost of training}}{\text{Annual operational savings + increase in revenue}} = \text{Payback period (in years)}$$

EXAMPLE OF PAYBACK PERIOD

A company is considering an all-inclusive clerical training program. The full cost of this training is $10,000. Company managers estimate that improved clerical effectiveness resulting from the training will save $1,200 per month ($14,400 per year). Should the company give further consideration to this training?

$$\frac{\$10,000}{\$14,400} = 0.69 \text{ years (about 8.3 months or 36 weeks)}$$

Yes, the company should consider the training further. Its payback period is very short, less than one year. Further calculation shows that, if the company's savings estimates are accurate, this investment (a) has a worthwhile cost-benefit ratio of only 0.69, and (b) will return 144% in the first year (the training year).

Advantages of the payback period method.

- Provides a quick initial look at a potential training investment.
- Answers the question, "How long will it take the training to pay for itself?"

Disadvantages of the payback period method.

- Should be used only as a screening tool. If the payback period is short, then another method (ROI, cost-benefit ratio, or bottom-line evaluation) must be used to examine the training's value, worth, and merit to the organization.
- Does not consider the cost or time value of the money spent and tied up before, during, and after the training until the break-even point is reached.

> Note. The advantages and disadvantages of the payback period method can be easily compared with those of the ROI, cost-benefit ratio, and bottom-line evaluation methods by consulting Table 1 on the following pages.

Table 1

Advantages and Disadvantages of Methods for Determining the Cost Effectiveness of Training

Advantages	Disadvantages
Return on investment (ROI)	
Provides an indicator of training's value, worth, and merit.	Appropriate only when it is possible to quantify outcomes (benefits) in monetary units.
Easily understood by higher management.	Baseline measures must be gathered for outcomes before training occurs.
Management will be impressed with favorable ROI report and view training as a value-added service.	Evidence of operational savings and increases in revenue available only after training is conducted. Therefore, ROI's application in predicting a favorable return is limited.
Cost-benefit ratio	
Especially suitable in situations where the benefits are difficult to quantify in monetary units.	Procedure used to predict benefits in monetary units is subjective.
Practical procedure that provides appropriate figures for benefits that are difficult to quantify.	
Shows whether training is worthwhile, before course or program is developed and delivered.	

(Table continues)

Table 1. (continued)

Advantages	Disadvantages
Bottom-line evaluation	
Promotes use of job analysis information.	Questionnaire responses are subjective perceptions by trainees.
Promotes employee participation in decision-making.	Questionnaire data might be biased.
Appeals to management, because it links job task performance with training and productivity.	
Total value added to the organization can be compared to full cost of training to determine if training was a worthwhile investment.	
Payback period	
Provides quick initial look at potential training investment.	Should be used only as screening tool. If payback period is short, then another method must be used to examine training's value, worth, and merit to organization.
Answers question, "How long will it take training to pay for itself?"	Does not consider cost or time value of money spent and tied up before, during, and after training until the break-even point is reached.

Progress Check -- Payback Period

Directions. Read each of the following items carefully and write in your answer. If you have difficulty with either item, go back and review the relevant content before continuing. Use a calculator or another sheet of paper for your calculations. Check your answers against those provided in the Progress Check Feedback at the end of this module.

1. Fixit Company is considering a training workshop for 12 employees. The full cost of the training workshop (for all 12 employees) is $9,000. The training manager has estimated that the additional training would enable the company to increase its revenue by $5,000 per year. He has decided that if the payback period was no more than 2 years, then he would give further consideration to the workshop.

   A. Calculate the payback period for this potential training investment.

      Payback period = ______________________________

   B. Should the training manager consider the training workshop further?

      Yes _______ No _______

      Why or why not?

      ____

      ____

Practical Example Skill Check

Background information. The training manager for the Camel Company had no interest in or idea how to determine the cost effectiveness of training. Consequently, the use of economic justification was avoided, and higher management came to view training as a cost of doing business. During an economic downturn, most of the training staff was cut as a result of "down-sizing." As a result, the training manager decided that he had better learn how to justify training as a worthwhile investment if he wanted to keep his job.

The training manager's first effort was to establish a "causal link" between a specific organizational problem and a performance deficiency. Finally, he had to provide evidence, in monetary units, that training was a worthwhile investment for the company.

Because the general manager of the Camel Company was accustomed to making decisions based on return on investment (ROI) reports, the training manager chose this method to justify the cost effectiveness of training.

Answers to the following items are provided in the Practical Example Skill Check Feedback at the end of this module.

I. List the three steps the training manager must take before preparing a return on investment (ROI) report for the general manager?

(1) ______________________________

____

(2) ______________________________

____

(3) ______________________________

____

<u>Practical Example Skill Check</u> (continued)

II. The following is a list of outcomes that could be measured. To prepare a **credible ROI report**, the evidence presented to the general manager should be described in which of the following terms? Place an X in front of those outcomes (benefits) which would provide convincing evidence that training was a worthwhile investment.

_____ 1. How those trained thought the training program went

_____ 2. Any increase in operational savings attributable to the training

_____ 3. Test scores showing that all trainees passed the post-test (final exam)

_____ 4. How efficient the trainees' supervisors thought the training program was

_____ 5. Increased revenue attributable to enhanced proficiency of the workers after training

_____ 6. Suggestions for improving/deleting parts of the training, derived from the training exit survey

_____ 7. Reduced medical claims attributable to safety awareness from the training program

_____ 8. Company executives' feelings about the training program

_____ 9. Reduced operational costs

Practical Example Skill Check (continued)

III. List the advantages and disadvantages of two other methods that the training manager could use to determine the cost effectiveness of training.

Method	Advantages	Disadvantages

Practical Example Skill Check (continued)

IV. Ten employees in the maintenance department went through a one-week (40-hour) training program. The training costs were as follows:

Cost item	Amount
Workers' total weekly compensation package (10 workers)	$ 8,500
Trainers' total weekly compensation package (2 trainers)	$ 4,200
Training development and instructional materials preparation	$ 1,000
Purchased instructional materials and consumable supplies	$ 450
Equipment rental	$ 1,000
Allocated facilities costs ($70 per day)	$ 350
Overhead and G & A expenses (total)	$ 500
Full cost of training	$16,000

Actual benefits of the program were difficult to quantify, However, the benefit item amounts listed on the next page were found by (a) taking figures for each item from the 12 monthly periods before the training; (b) then obtaining an average of the 12 figures for each item reported; (c) calculating each item's average monthly benefit (the difference between the item average and the figure for the same item after training); and (d) annualizing the resulting monthly benefit (by multiplying by 12).

Practical Example Skill Check (continued)

IV. (continued)

Benefit item	Annualized benefit amount from training
Operational costs (reduced)	$ 9,600
Productivity (increased)	$13,200
Absenteeism (decreased)	$ 3,000
Quality (improved)	$ 2,400
Total annual benefit	$28,200

After applying, back on the job, what they learned in training, the employee/trainees completed a questionnaire. The response data indicated that, on average,

(1) 35% of their job-time was spent performing the task trained

(2) Their productivity in performing the task trained improved 28% as a direct result of the training.

Using the information given (in item IV), and the payback period method, how long before the break-even point for this training was reached? Show all calculations.

Payback period = ______________________________

____

Practical Example Skill Check (continued)

V. Continuing with the information from item IV, and using the ROI, cost-benefit ratio, and bottom-line evaluation methods, determine if this training should be continued or terminated. Describe your rationale. Use the following criteria: "Any activity in which the organization is involved, including any department within the organization, should add appreciably to our goal of 11.5% increase in total annual revenue over the next five years." (from Camel Company's *Vision, Values, and Goals* statement.)

ROI = ______________________________

Cost-benefit ratio (using calculated costs and benefits) =

____

Bottom-line evaluation (total value added) =

____

____

Determination:

Continue the training _______

Terminate the training _______

Rationale:

____

____

____

____

____

____

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<u>**Progress Check Feedback**</u> **--**

Part 1 – Training Costs (pp. 15-17)

1. Identify the greatest incentive for indicating the cost effectiveness of training.

   Justifying training expenditures with documented benefits (p. 4)

2. Name two categories of training costs.

   (1) *direct costs*

   (2) *indirect costs (p. 5)*

3. Calculate the total daily (8-hour) compensation package for an employee whose hourly wage is $16, and whose fringe benefits package costs his employer an additional 29%.

   Total daily compensation package =

   ($16 x 8 hours) + (29% x $16 x 8 hours) = $165.12

4. Calculate the training costs for 12 trainees, with individual total compensation packages of $195 per day, who attend a 5-day training program.

   Total trainee costs = *12 trainees x 5 days x $195 = $11,700*

5. Calculate the instructor costs for a 5-day workshop with one instructor who requires 2 additional days for preparation. The instructor's direct salary is $180 per day, with a 30% fringe benefits package.

   Total instructor costs =

   1 instructor x (5 + 2 days) x [$180 + ($180 x 30%)] = $1,638

6. Calculate the training development and instructional materials preparation costs for two developers, with a total daily compensation package cost to the organization of $220 each, who worked 5 days on developing training and 8 days on preparing instructional materials. The cost of supplies used in preparing the instructional materials was $210.

   Total development and preparation costs =

   [2 developers x (8 + 5 days) x $220] + $210 = $5,930

<u>Progress Check Feedback</u> -- Part 1 -- Training Costs (continued)

7. The cost of developing training and preparing printed instructional materials for a 5-day seminar was $6,300.
   A. What will be the cost per seminar if it is offered once each month for one year?
      Cost per seminar = *$6,300 ÷ 12 times offered = $525*
   B. If the seminar is offered only twice, to a total of 30 trainees (15 in each session), what will be the cost per trainee?
      Cost per trainee = *$6,300 ÷ 30 trainees = $210*
8. The employer purchased books and modules for each of 12 trainees, costing a total of $180 per trainee. Paper and pencils, which cost $45 total, were also required. Calculate the total cost of these instructional materials.
   Total instructional materials costs =
   ($180 x 12 trainees) + $45 = $2,205
9. Welding Associates rented equipment for a 4-day training program they are conducting. The rental cost for the equipment is $300 per day. Maintenance costs associated with the equipment are $20 per day. What will be the equipment costs for this training program?
   Equipment costs = *4 days x ($300 + $20) = $1,280*
10. Welding Associates is considering purchasing the arc welding machine needed for training. The machine's purchase price is $22,500 and its estimated useful life is 5 years. In addition, yearly maintenance costs for the purchased machine are expected to be $2,100.
    A. What will be the total annual cost of the machine?
       Total annual equipment cost =
       ($22,500 ÷ 5 years) + $2,100 = $6,600
    B. If Welding Associates uses the machine in a training program offered 12 times per year, what will be the equipment cost for each program?
       Equipment cost per training program =
       $6,600 annual cost ÷ 12 times offered = $550

<u>Progress Check Feedback</u> -- Part 1 — Training Costs (continued)

11. Welding Associates estimated their total facilities costs, including maintenance, for the current year to be $40,000.
    A. If the facilities are used 15% of the time for training, what portion of the facilities costs should be allocated to the training budget?
    Facilities costs (for training) = *<u>$40,000 x 15% = $6,000</u>*
    B. If the facilities are used for training 5 days per week, 48 weeks per year *<u>[5 days x 48 weeks = 240 days per year]</u>*, what is the daily facilities rate for the use of these facilities?
    Daily facilities rate = *<u>$40,000 ÷ 240 days = $166.67</u>*
12. Six welders will travel from their home to another city to attend a 3-day workshop where they will learn to use specialized equipment. Welding Associates agreed to pay each employee's $400 airfare plus $75 per day for other expenses. Calculate the travel and per diem costs incurred by Welding Associates for this 3-day workshop.
    Travel and per diem costs =
    <u>(6 welders x 3 days x $75) + (6 x $400 air fare) = $3,750</u>
13. Welding Associates found their total direct costs for a training program to be $17,000. Indirect costs, consisting of allocated overhead and G & A expenses, totalled $2,000. What was Welding Associates' full cost of training?
    Full cost of training = *<u>$17,000 + $2,000 = $19,000</u>*

<u>**Progress Check Feedback --**</u>

Part 2 – Training Effectiveness (p. 21)

1. Kirkpatrick noted that the effectiveness of training can be measured at four different levels. Briefly describe the levels.

   (1) *(See page 18)* ______________________________

   ____

   (2) ______________________________

   ____

   (3) ______________________________

   ____

   (4) ______________________________

   ____

2. Is it possible and/or feasible to link training outcomes to organizational improvements without the absolute isolation of training's benefits from the possible contributions of other variables?

   __*X*__ Yes, it is both possible and feasible. *(p. 18)*

   ______ It is possible, but not feasible.

   ______ It is feasible, but not possible.

   ______ No, it is neither possible nor feasible.

3. What is the key to collecting evidence of training outcomes?

   Establish a causal link between a specific organizational problem, preferably a problem to which monetary value can be assigned, and a performance deficiency. (p. 19)

4. Identify the result of selecting the outcomes to be measured and linking training to those outcomes.

   Level 4 measurement becomes a relatively simple matter. (p. 19)

Progress Check Feedback --

Return on Investment (ROI) (p. 26)

1. A technical training program is saving your organization $20,000 per year and has increased revenue by $26,000 per year. The full cost of training was $40,000.

   A. What was the ROI of this training investment?

      ROI = *($20,000 + $26,000) ÷ $40,000 = 1.15 or 115%*

   B. Was this a worthwhile investment?

      Yes *X* No ____

      Why or why not?

      The ROI is greater than one (1.0), the break-even point. The training investment is returning 115% per year. The first year, this is the original training investment plus an additional $6,000 (or 15%). The training will no doubt continue to provide a benefit, even without additional investment.

   C. Would your opinion change if you could have invested the $40,000 in a savings fund at a guaranteed 17% annual return instead?

      Yes ____ No *X*

      Why or why not?

      In the first year, the 17% return on savings would be better than the 15% return from the training investment. However, the training investment will no doubt continue to provide a return without an additional investment.

<u>Progress Check Feedback</u> --

Cost-Benefit Ratio (p. 30)

1. Mr. Whiz predicted that a computer technician training program for two of his employees would result in a total cost savings of $9,000 per year in computer repairs and down-time. He rates his level of confidence, that the training will be responsible for this savings, at 80%. The projected full cost of the technician training is $2,000 per person.

A. Calculate the cost-benefit ratio for this potential training investment.

Cost-benefit ratio =

(2 trainees x $2,000) ÷ ($9,000 x 80%) = 0.556

B. Do you think this training would be a worthwhile investment for Mr. Whiz's company?

Yes *X* No ______

Why or why not?

The cost-benefit ratio of this potential training investment is less than one (1.0). (p. 27)

<u>**Progress Check Feedback --**</u>

Bottom-Line Evaluation (pp. 35-36)

1. A training manager has identified all the tasks performed by each employee within the organization, along with their total compensation packages. The training department is providing a welding training program for the welding department's four employees, at a total cost of $4,400. Each welder has a total annual compensation package of $20,000. The training manager would like to present training's value to higher management. The training is delivered and questionnaire results, in table form, are as follows.

Employee/ trainee	Total annual compensation package ($) [S]	Job-time (%) spent performing the task trained [T]	Component pay ($) [D = SxT]	Pre-training productivity (%) [P1]	Post-training productivity (%) [P2]	Productivity gain (%) [G = P2-P1]	Value added ($) [GxD]
1	*$20,000*	10%	*$2,000*	20%	60%	*40%*	*$ 800*
2	*$20,000*	40%	*$8,000*	20%	50%	*30%*	*$2,400*
3	*$20,000*	30%	*$6,000*	30%	50%	*20%*	*$1,200*
4	*$20,000*	20%	*$4,000*	40%	60%	*20%*	*$ 800*
Total value added							*$5,200*

A. Complete the table. For each employee, you will need to calculate component pay, productivity gain, and value added. You will also need to calculate the training program's total value added to the organization.

B. Was the training program worthwhile?

Yes *X* No ______

Why or why not?

The value added to the organization by the training ($5,200) was greater than the training investment ($4,400).

Progress Check Feedback --

Payback Period (p. 42)

1. Fixit Company is considering a training workshop for 12 employees. The full cost of the training workshop (for all 12 employees) is $9,000. The training manager has estimated that the additional training would enable the company to increase its revenue by $5,000 per year. He has decided that if the payback period was no more than 2 years, then he would give further consideration to the workshop.

   A. Calculate the payback period for this potential training investment.

   Payback period = *$9,000 ÷ $5,000 = 1.8 years*

   B. Should the training manager consider the training workshop further?

   Yes ___*X*___ No _______

   Why or why not?

   The payback period was less than the training manager's cut-off of 2 years.

Practical Example Skill Check Feedback (pp. 43-48)

I. List the three steps the training manager must take before preparing a return on investment (ROI) report for the general manager?

(1) *Calculate the direct and indirect costs associated with the training. Then add these costs to obtain the full cost of training.*

(2) *Baseline (before training) those outcomes to be analyzed in step 3.*

(3) *Analyze the effects of training on the outcomes (benefits) in monetary units. (p. 22)*

II. The following is a list of outcomes that could be measured. To prepare a **credible ROI report**, the evidence presented to the general manager should be described in which of the following terms? Place an X in front of those outcomes (benefits) which would provide convincing evidence that training was a worthwhile investment.

_____ 1. How those trained thought the training program went

X 2. Any increase in operational savings attributable to the training *(pp. 22-23)*

_____ 3. Test scores showing that all trainees passed the final exam

_____ 4. How efficient the trainees' supervisors thought the training program was

X 5. Increased revenue attributable to enhanced proficiency of the workers after training *(pp. 22-23)*

_____ 6. Suggestions for improving/deleting parts of the training, derived from the training exit survey

X 7. Reduced medical claims attributable to safety awareness from the training program *(p. 22)*

_____ 8. Company executives' feelings about the training program

X 9. Reduced operational costs *(pp. 22-23)*

Practical Example Skill Check Feedback (continued)

III. List the advantages and disadvantages of two other methods that the training manager could use to determine the cost effectiveness of training.

Method	Advantages	Disadvantages

(See Table 1, pages 40 and 41)

Practical Example Skill Check Feedback (continued)

IV. Ten employees in the maintenance department went through a one-week (40-hour) training program. The training costs were as follows:

Cost item	Amount
Workers' total weekly compensation package (10 workers)	$ 8,500
Trainers' total weekly compensation package (2 trainers)	$ 4,200
Training development and instructional materials preparation	$ 1,000
Purchased instructional materials and consumable supplies	$ 450
Equipment rental	$ 1,000
Allocated facilities costs ($70 per day)	$ 350
Overhead and G & A expenses (total)	$ 500
Full cost of training	$16,000

Actual benefits of the program were difficult to quantify. However, the benefit item amounts listed on the next page were found by (a) taking figures for each item from the 12 monthly periods before the training; (b) then obtaining an average of the 12 figures for each item reported; (c) calculating each item's average monthly benefit (the difference between the item average and the figure for the same item after training); and (d) annualizing the resulting monthly benefit (by multiplying by 12).

Practical Example Skill Check Feedback (continued)

IV. (continued)

Benefit item	Annualized benefit amount from training
Operational costs (reduced)	$ 9,600
Productivity (increased)	$13,200
Absenteeism (decreased)	$ 3,000
Quality (improved)	$ 2,400
Total annual benefit	$28,200

After applying, back on the job, what they learned in training, the employee/trainees completed a questionnaire. The response data indicated that, on average,

(1) 35% of their job-time was spent performing the task trained

(2) Their productivity in performing the task trained improved 28% as a direct result of the training.

Using the information given (in item IV), and the payback period method, how long before the break-even point for this training was reached? Show all calculations.

Payback period = *$16,000 ÷ $28,200 = 0.57 years (about 6.8 months or 29.5 weeks)*

<u>**Practical Example Skill Check Feedback**</u> (continued)

V. Continuing with the information from item IV, and using the ROI, cost-benefit ratio, and bottom-line evaluation methods, determine if this training should be continued or terminated. Describe your rationale. Use the following criteria: "Any activity in which the organization is involved, including any department within the organization, should add appreciably to our goal of 11.5% increase in total annual revenue over the next five years." (from Camel Company's *Vision, Values, and Goals* statement.)

ROI = *$28,200 ÷ $16,000 = 1.76 or 176%*

Cost-benefit ratio (using calculated costs and benefits) =
$16,000 ÷ $28,200 = 0.57

Bottom-line evaluation (total value added) =
[($8,500 x 52 weeks) x 35% job-time on task] x 28% improvement = $43,316

Determination:

Continue the training *X*

Terminate the training ______

Rationale:

- *The training returns the investment plus an additional 76% in the first year, far more than the stipulated 11.5% annual return.*
- *The cost-benefit ratio is well below one (1.0).*
- *The value added to the organization by the training is more than 2 times greater than the training investment.*

Prepared by C^2 Mar. 94
Tested & Revised June 94
Revised April 96

Appendix B

Human Subjects Disclosure and Administrative Procedure

Administration Procedures

Cost Effectiveness of Training

You are part of a sample from industrial employers within the Walters State Community College service area of East Tennessee. As human resource training professionals, you have been asked to participate with a tutorial to learn how to determine the cost effectiveness of training.

Since this is a voluntary program, your name will not be associated with scores. You may withdraw without penalty. Completion of the tutorial constitutes your consent to participate in this study. Your name is not associated with the materials, the survey, nor the resulting progress test.

You have been randomly assigned a method of instruction, either paper based or computer based. A number is assigned to your survey package. Remember the number for your personal identification of post-test scores. This number doubles as **a pass code for the self-check program of the computer-based tutorial**.

To learn more about the training methods and how participants interact with them, your completion time is recorded. How fast you progress is totally unimportant. Work at your own pace. Be sure that you complete each of the four divisions to the materials before progressing to another part. The divisions are:

- First, the objectives, rationale, and introduction
- Second, Part 1 -- Training Costs
- Third, Part 2 -- Training Effectiveness
- Part 3 -- Methods Used To Determine the Cost Effectiveness of Training

Both Part 1 and Part 2 are followed by a progress check. Part 3 has short subdivisions; each followed by a progress check. They are

- Return On Investment (ROI)
- Cost-Benefit Ratio
- Bottom-Line Evaluation
- Payback Period

Two instruments are to be administered at the end of the training module. A satisfaction scale and a cognitive test. Please take your time. None of the instruments will have your name associated with them.

In order to track the time required to take the training module, as you start record the time. As you finish the last of Part 3, the Payback Period, verify your completion of the tutorial, record the completion time. Place the materials back in the envelope and return them to the administrator.

Please record tutorial:

start time _______

completion time _______

Appendix C

Cognitive Test, Answer Sheet and Tables for Scoring

Posttest

The following is a test taken directly from the training criteria and objectives. This test will not be counted against you since your name is not associated with it.
You may use the training material during the test.

Practical Example Skill Check

Background information. The training manager for the Camel Company had no interest in or idea how to determine the cost effectiveness of training. Consequently, the use of economic justification was avoided, and higher management came to view training as a cost of doing business. During an economic downturn, most of the training staff was cut as a result of "down-sizing." As a result, the training manager decided that he had better learn how to justify training as a worthwhile investment if he wanted to keep his job. The training manager's first effort was to establish a "causal link" between a specific organizational problem and a performance deficiency. Finally, he had to provide evidence, in monetary units, that training was a worthwhile investment for the company.

Because the general manager of the Camel Company was accustomed to making decisions based on return on investment (ROI) reports, the training manager chose this method to justify the cost effectiveness of training.

Answer the following items:

I. List the three steps the training manager must take before preparing a return on investment (ROI) report for the general manager?

(1) ______________________________

____

(2) ______________________________

____

(3) ______________________________

____

Practical Example Skill Check (continued)

II. The following is a list of outcomes that could be measured. To prepare a **credible ROI report**, the evidence presented to the general manager should be described in which of the following terms? Place an X in front of those outcomes (benefits) which would provide convincing evidence that training was a worthwhile investment.

____ 1. How those trained thought the training program went

____ 2. Any increase in operational savings attributable to the training

____ 3. Test scores showing that all trainees passed the post-test (final exam)

____ 4. How efficient the trainees' supervisors thought the training program was

____ 5. Increased revenue attributable to enhanced proficiency of the workers after training

____ 6. Suggestions for improving/deleting parts of the training, derived from the training exit survey

____ 7. Reduced medical claims attributable to safety awareness from the training program

____ 8. Company executives' feelings about the training program

____ 9. Reduced operational costs

Practical Example Skill Check (continued)

III. List the advantages and disadvantages of two other methods that the training manager could use to determine the cost effectiveness of training.

Method	Advantages	Disadvantages

Practical Example Skill Check (continued)

IV. Ten employees in the maintenance department went through a one-week (40-hour) training program. The training costs were as follows:

Cost item	Amount
Workers' total weekly compensation package (10 workers)	$ 8,500
Trainers' total weekly compensation package (2 trainers)	$ 4,200
Training development and instructional materials preparation	$ 1,000
Purchased instructional materials and consumable supplies	$ 450
Equipment rental	$ 1,000
Allocated facilities costs ($70 per day)	$ 350
Overhead and G & A expenses (total)	$ 500
Full cost of training	$16,000

Actual benefits of the program were difficult to quantify. However, the benefit item amounts listed on the next page were found by (a) taking figures for each item from the 12 monthly periods before the training; (b) then obtaining an average of the 12 figures for each item reported; (c) calculating each item's average monthly benefit (the difference between the item average and the figure for the same item after training); and (d) annualizing the resulting monthly benefit (by multiplying by 12).

Practical Example Skill Check (continued)

IV. (continued)

Benefit item	Annualized benefit amount from training
Operational costs (reduced)	$ 9,600
Productivity (increased)	$13,200
Absenteeism (decreased)	$ 3,000
Quality (improved)	$ 2,400
Total annual benefit	$ 28,200

After applying, back on the job, what they learned in training, the employee/trainees completed a questionnaire. The response data indicated that, on average,

(1) 35% of their job-time was spent performing the task trained

(2) Their productivity in performing the task trained improved 28% as a direct result of the training.

Using the information given (in item IV), and the payback period method, how long before the break-even point for this training was reached? Show all calculations.

Payback period = ______________________________

____

<u>Practical Example Skill Check</u> (continued)

V. Continuing with the information from item IV, and using the ROI, cost-benefit ratio, and bottom-line evaluation methods, determine if this training should be continued or terminated. Describe your rationale. Use the following criteria: "Any activity in which the organization is involved, including any department within the organization, should add appreciably to our goal 11.5% increase in total annual revenue over the next five years." (from Camel Company's Vision, Values, and Goals statement.)

ROI = ______________________________

Cost-benefit ratio (using calculated costs and benefits) = ______________________________

____

Bottom-line evaluation (total value added) = ______________________________

____

____

Determination:

Continue the training ______

Terminate the training ______

Rationale:

____

____

____

____

____

Posttest Score Sheet

Each question below has a weighted value listed in bold print.
Score answers accordingly.

I. List the three steps the training manager must take before preparing a return on investment (ROI) report of the general manager?

Score **Each answer = 2 points**

____ (1) *Calculate the direct and indirect costs associated with the training. Then add these costs to obtain the full cost of training.*

____ (2) *Baseline (before training) those outcomes to be analyzed in step 3.*

____ (3) *Analyze the effects of training on the outcomes (benefits) in monetary units. (p. 22)*

II. The following si a list of outcomes that could be measured. To, prepare a **Credible ROI report**, the evidence presented to the general manager should be described in which of the following terms? Place an X in front of those outcomes (benefits) which would provide convincing evidence that training was a worthwhile investment.

Each answer = 2 points. Deduct if not as shown below.

Score	Answer	
____	____	1. How those trained thought the training program went.
____	*X*	2. Any increase in operational savings attributable to the training *(pp. 22-23)*
____	____	3. Test scores showing that all trainees passed the final exam
____	____	4. How efficient the trainees' supervisors thought the training program was
____	*X*	5. Increased revenue attributable to enhanced proficiency of the workers after training *(pp. 22-23)*
____	____	6. Suggestions for improving/deleting parts of the training, derived from the training exit survey
____	*X*	7. Reduced medical claims attributable to safety awareness from the training program *(p. 22)*
____	____	8. Company executives' feelings about the training program
____	*X*	9. Reduced operational costs *(pp. 22-23)*

Posttest Score Sheet

III. List the advantages and disadvantages of two other methods that the training manager could use to determine the cost effectiveness of training.

The total of answers on this page = 24 points – method = 4 points, advantages and disadvantages = 4 points each. A correct method = 4 points.
The total of method advantages & disadvantages = 8 points, sub-answers advantages = 1.33 points each for a total of 4 points per category.

Score

_____ **Method – Return On Investment (ROI)**

Advantages

_____ Provides an indicator of training's value, worth, and merit.

_____ Easily understood by higher management.

_____ Management will be impressed with favorable ROI report and view training as a value-added service

Disadvantages

_____ Appropriate only when it is possible to quantify outcomes (benefits in monetary units.

_____ Baseline measures must be gathered for outcomes before training occurs.

_____ Evidence of operational savings and increases in revenue available only after training is conducted. Therefore, ROI's application in predicting a favorable return is limited.

Formulae – $$\frac{\textbf{Operational Savings + Increase in Revenue}}{\textbf{Full Cost of Training}} = \textbf{ROI}$$

If > 1 Benefits exceed costs – continue training
If < 1 Benefits less than costs – cease training

Score

_____ **Method – Cost-Benefit Ratio (CBR)**

Advantages

_____ Especially suitable in situations where the benefits are difficult to quantify in monetary units.

_____ Practical procedure that provides appropriate figures for benefits that are difficult to quantify.

_____ Shows whether training is worth-while, before course or program is developed

Disadvantage

_____ Procedure used to predict benefits in monetary units is subjective

Formulae – $$\frac{\textbf{Projected full cost of training}}{\textbf{Predicted training benefits}} = \textbf{CBR}$$

If < 1 Benefits exceed costs – training is worthwhile
If > 1 Costs exceed benefits

Posttest Score Sheet

(Question III. Continued)

The total of answers on this method = 12 points -- method = 4 points, advantages and disadvantages = 4 points each. A correct method = 4 points. The total of method advantages & disadvantages = 8 points Sub-answers for advantages = 1 point each for a total of 4 points Sub-answers for disadvantages = 2 points for a total of 4 points

---

Score

____ **Method -- Bottom-Line Evaluation**

Advantages

____ Promotes use of job analysis information.

____ Promotes employee participation in decision-making.

____ Appeals to management, because it links job task performance with training and productivity.

____ Total value added to the organization can be compared to full cost of training to determine if training was a worth while investment.

Disadvantages

____ Questionnaire responses are subjective perceptions by trainees.

____ Questionnaire data might be biased.

Formulae -- (S x T) x (P2 - P1) = Value Added
S = Compensation Package
T = Percent of job time performing tasks
P1 = Pre-training productivity
P2 = Post-training productivity

(Annual compensation x % time on job (task total))
X
(% change in productivity as a result of training) = Value Added

---

The total of answers on this method = 12 points -- method = 4 points, advantages and disadvantages = 4 points each. A correct method = 4 points. The total of method advantages & disadvantages = 8 points Sub-answers for advantages & disadvantages = 2 points each

---

Score

____ **Method -- Payback Period**

Advantages

____ Provides quick initial look at potential

____ Answers question, "How long will it take training to pay for itself?"

Disadvantages

____ Should be used only as screening tool. If payback period is short, then another method must be used to examine training's value, worth, and merit to organization.

____ Does not consider cost or time value of money spent and tied up before, during, and after training until the break-even point is reached.

Formulae -- $\frac{\text{Full cost of training}}{\text{Annual operational savings + Increase in revenue}}$ = Payback Period in years

Posttest Score Sheet

Score

IV. Ten employees in the maintenance department went through a one-week (40-hour) training program. The training costs were as follows:

Cost item	Amount
Workers' total weekly compensation package (10 workers)	$ 8,500
Trainers; total weekly compensation package (2 trainers)	$ 4,200
Training development and instructional materials preparation	$ 1,000
Purchased instructional materials and consumable supplies	$ 450
Equipment rental	$ 1,000
Allocated facilities costs ($70 per day)	$ 350
Overhead and G & A expenses (total)	$ 500
Full cost of training	$16,000

Actual benefits of the program were difficult to quantify. However, the benefit item amounts listed on the next page were found by (a) taking figures for each item from the 12 monthly periods before the training: (b) then obtaining an average of the 12 figures for each item reported: (c) calculating each item's average monthly benefit (the difference between the item average and the figure for the same item after training): and (d) annualizing the resulting monthly benefit (by multiplying by 12).

Posttest Score Sheet

Score

IV. (Question IV. Continued)

Benefit item	Annualized benefit amount from training
Operational costs (reduced)	$ 9,600
Productivity (increased)	$13,200
Absenteeism (decreased)	$ 3,000
Quality (improved)	$ 2,400
Total annual benefit	$28,200

After applying, back on the job, what they leamed in training, the employee/trainees completed a questionnaire.

The response data indicated that , an average,

(1) 35% of their job-time was spent performing the task trained

(2) Their productivity in performing the task trained improved 28% as a direct result of the training.

Using the information given (in item IV), and the payback period method, how long before the break-even point for this training was reached? Show all calculations.

Payback - 4 points -- each number is 1 point (numerator and denominator), the proper formulae is one point, the proper answer is 1 point for a 4 points total.

_____ **Payback Period =** $16,000 ÷ $28,000 = 0.57 years (about 6.8 months or 29.5) years

Posttest Score Sheet

Score

ROI, Cost-benefit ratio, & Bottom-line evaluation = 4 points each.

The remaining answers are worth 2 points each.

V. Continuing with the information from item IV, and using the ROI, cost-benefit ratio, and bottom-line evaluation methods, determine if this training should be continued or terminated. Describe your rationale. Use the following criteria: "Any activity in which the organization is involved, including any department within the organization, should add appreciably to our goal of 11.5% increase in total annual revenue over the next five years." (from Camel Company's Vision, Values, and Goals statement.)

_____ **ROI** = $28,200 ÷ $16,000 = 1.76 or 176%

_____ **Cost-benefit ratio** (using calculated costs and benefits) = $16,000 ÷ $28,200 = 0.57

_____ **Bottom-line evaluation** (total value added) =

[($8,500 x 52 weeks) x 35% job-time on tasks] x 28% improvement = $43,316

_____ **Determination:**

Continue the training __X__

Terminate the training ____

Rationale:

_____ The training returns the investment plus an additional 76% in the first year, for more than the stipulated 11.5% annual return

_____ The cost-benefit ratio is well below one (1.0).

_____ The value added to the organization by the training is more than 2 times greater then the training investment.

See Posttest Answer Sheet for Weighted Values

Posttest Score Table

Posttest Questions	Sample Population											
	A	B	C	D	E	F	G	H	I	J	K	L
I.1												
I.2												
I.3												
II.1												
II.2												
II.3												
II.4												
II.5												
II.6												
II.7												
II.8												
II.9												

Posttest Score Table

(Continued)

Posttest Questions	Sample Population											
	A	B	C	D	E	F	G	H	I	J	K	L
III. Method #1												
III. Advantage-1, Total												
III. Disadvantages-1, Total												
III. Method #2												
III. Advantage-2 Total												
III. Disadvantages-2, Total												
IV.1 Payback Period												
V.1 ROI												
V.2 CBR												
V.3 Bottom-line Eval.												
V.4 Determination												
V.5 Rationale 1												
V.5 Rationale 2												
V.5 Rationale 3												
Total Correct												

Appendix D

Satisfaction Rating Instrument Forms and Tables for Scoring

Satisfaction Rating

This is a 23 question survey to assist in the analysis of training methods. You have been presented one of two different forms of the same instrument (computerized or paper based). Please respond accurately to all 23 statements. The instructional method statement below and at the top of the next page (bold type and underlined) is the same for all statements.

The scale is 1 strongly disagree to 9 strongly agree -- **(1) strongly disagree (9) strongly agree**

The instructional method (presentation of lessons) for Determining the Cost Effectiveness of Training in which I was involved:

		strongly disagree								strongly agree
1.	was satisfying to me once completed	1	2	3	4	5	6	7	8	9
2.	limited my opportunity for observation	1	2	3	4	5	6	7	8	9
3.	did not teach knowledge together with skills	1	2	3	4	5	6	7	8	9
4.	provided me with unsatisfactory task explanations	1	2	3	4	5	6	7	8	9
5.	provided for my individual difference in learning style	1	2	3	4	5	6	7	8	9
6.	emphasized identifiable main goals for me	1	2	3	4	5	6	7	8	9
7.	allowed no opportunity for me to conform to the instructional method	1	2	3	4	5	6	7	8	9
8.	did not provide me an alternate path for learning	1	2	3	4	5	6	7	8	9
9.	developed a working vocabulary as I progressed	1	2	3	4	5	6	7	8	9
10.	emphasized learning , through practice, learning by doing	1	2	3	4	5	6	7	8	9

The scale is 1 strongly disagree to 9 strongly agree – **(1) strongly disagree (9) strongly agree**

The instructional method (presentation of lessons) for Determining the Cost Effectiveness of Training in which I was involved:

		strongly disagree								strongly agree
11.	did not include training for me on specifics	1	2	3	4	5	6	7	8	9
12.	did not maximize my own performance.	1	2	3	4	5	6	7	8	9
13.	was frustrating to me	1	2	3	4	5	6	7	8	9
14.	encouraged me with helps.	1	2	3	4	5	6	7	8	9
15.	was adaptable to meet my individual needs	1	2	3	4	5	6	7	8	9
16.	required excessive effort for the benefits I received	1	2	3	4	5	6	7	8	9
17.	embedded learning in the application environment	1	2	3	4	5	6	7	8	9
18.	created an expert model for me to follow	1	2	3	4	5	6	7	8	9
19.	provided me continuous support throughout the process	1	2	3	4	5	6	7	8	9
20.	allowed me to acquire experience	1	2	3	4	5	6	7	8	9
21.	was an unsatisfactory presentation format for my particular situation	1	2	3	4	5	6	7	8	9
22.	limited my learning by restriction of interaction between administrator and myself	1	2	3	4	5	6	7	8	9
23.	I prefer paper to computers	1	2	3	4	5	6	7	8	9

Individual Code Sheet

For administration purposes only -- do not mark on this sheet

Random Order	Groupings Questions From Each Letter Group Are Related	Original Order Before Randomization	Inversion	1 score 9
1		4		
2	A	9	invert before scoring	
3		7	invert before scoring	
4	B	13	invert before scoring	
5	B	21		
6		19		
7		22	invert before scoring	
8	C	18	invert before scoring	
9	B	14		
10	A	2		
11	A	10	invert before scoring	
12		5	invert before scoring	
13	B	15	invert before scoring	
14	B	16		
15	C	11		
16		20	invert before scoring	
17		6		
18		17		
19	B	12		
20	A	8		
21	C	3	invert before scoring	
22		1	invert before scoring	
23		23	invert before scoring	

Population Score Sheet for Satisfaction Rating

Survey Statements	Sample Population											
	A	B	C	D	E	F	G	H	I	J	K	L
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												

Appendix E

Computer Source Files

for the Computer Job-Aid

Cost Effectiveness of Training in 49 Files

Below are listings of computer source files used to construct the knowledge base. The (.txt) file extension are ascii files taken from the original manuscript; (.hpw) are hypertext, (.bmp) are bitmapped graphics, and (.ppt) are presentation media. Files with common prefix but different suffix, for example (cost2ratl), usually will contain the same information with different computer format; the exceptions is noted as graphic (.bmp), session (.ses), auto-logging (.log), or audio (.wav) files.

I. Determining the cost effectiveness of training	***Cost.txt, or hpw***
Credit Screen Graphic – Pre-welcome	***Credit.bmp***
Presentation Graphic – welcome & Hot Spot scre	***Cost.bmp***
Graphic Screen – for Objectives, Rationale & Introduction	***Geninf.bmp***
Learning Objectives	***Cos_obj.txt, ppt, or hpw***
A. Rationale	***Cos2ratl.txt, ppt, or hpw***
B. Introduction	***Cos3int.txt, ppt,,or hpw***
II. Part 1 – Training Costs	***Cos4tran.txt, ppt, or hpw***
A. Training Costs – When to measure the cost effectiveness	***Cos5tra1.txt, ppt, or hpw***
B. Calculating the costs of training	***Cos6tra2.txt, ppt, or hpw***
1. Ex. of total compensation package	*Cos6ex1.txt, bmp, or hpw*
2. Ex. of trainee costs	*Cos6ex2.txt, bmp, or hpw*
3. Ex. of instruction costs	*Cos6ex3.txt, bmp, or hpw*
4. Ex. of training development and instructional materials preparation costs	*Cos6ex4.txt, bmp, or hpw*
5. Ex. of instructional materials costs	*Cos6ex5.txt, bmp, or hpw*
6. Ex. of rented equipment costs	*Cos6ex6.txt, bmp, or hpw*
7. Ex. of purchased equipment costs	*Cos6ex7.txt, bmp, or hpw*
8. Ex. of facilities costs	*Cos6ex8.txt, bmp, or hpw*
9. Ex. of travel and per diem costs	*Cos6ex9.txt, bmp or hpw*
10. Ex. of full cost of training calculation	*Cos6ex10.txt, bmp or hpw*
C. Progress check – Part 1 – Training Costs	***Cos7trat.txt, bat orhpw***
Feedback Review	Cos_trat.txt, or hpw
III. Part 2 – Training Effectiveness	
A. Training Effectiveness	*Cos8eff.txt, **ppt, or hpw***
1. Looking toward part 3	*Cos8mce.txt, ppt, or hpw*

B. Progress Check – Part 2 – Training Effectiveness	***Cos9efft.txt**, bat, or hpw*
Feedback Review	Cos_efft.txt, or hpw
IV. Part 3 – Methods Used to Determine	
the Cost Effectiveness of Training	***Cos10mce.txt, ppt, or hpw***
A. Return on Investment (ROI)	***Cos10roi.txt, ppt, or hpw***
1. Formula – (ROI)	*Cos10fla.txt, bmp, or hpw*
2. Example –(ROI)	*CosEXroi.txt, bmp, or hpw*
3. Progress Check – Return on Investment (ROI)	***Cos11roi.txt, or hpw***
Feedback Review	Cos_roit.txt, or hpw
B. Cost-Benefit Ratio	***Cos12cbr.txt, ppt, or hpw***
1. Formula – Cost-Benefit Ratio	*Cos12fla.txt, bmp, or hpw*
2. Example – Cost-Benefit Ratio	*CosEXcbr.txt, bmp, or hpw*
3. Progress Check – Cost-Benefit Ratio	***Cos13brt.txt, or hpw***
Feedback Review	Cos_cbrt.txt, or hpw
C. Bottom-Line Evaluation	***Cos14bl.txt, ppt, or hpw***
1. Formula – Bottom-Line Evaluation	*Cos14fla.txt, bmp, or hpw*
2. Example – Bottom-Line Evaluation	*CosEXble.txt, ppt, or hpw*
3. Progress Check – Bottom-Line Evaluation	***Cos15blt.txt, or hpw***
Feedback Review	Cos_blet.txt, or hpw
D. Payback Period	***Cos16pb.txt, ppt, or hpw***
1. Formula – Payback Period	*Cos16fla.txt, bmp, or hpw*
2. Example – Payback Period	*CosEXpb.txt, bmp, or hpw*
3. Progress Check – Payback Period	***Cos17pbt.txt, or hpw***
Feedback Review	Cost_pbt.txt, or hpw
E. Table – Advantages and Disadvantages	***Costable.txt, ppt, or hpw***
1. Table Graphical – Return on Investment	*Costabl1.bmp*
2. Table Graphical – Cost-Benefit Ratio	*Costabl2.bmp*
3. Table Graphical – Bottom-Line Evaluation	*Costabl3.bmp*
4. Table Graphical – Payback Period	*Costabl4.bmp*
F. Practical Example Skill Check	***Costexsc.txt, or hpw***
G. Reference	***Costref.txt, or hpw***
H. Progress Check Feedback	***Costfdbk.txt, or hpw***

V. Save Session and Restore Session file for auto-rewind	
1. Welcome screen	***Cost.ses***
2. Objectives, Rational & Intro. Screen	***Cost_.ses***
3. Part 1 –	***Cost1.ses***
4. Part 2 –	**Cost2.ses**
5. Part 3 –	**Cost3.ses**
VI. Log file for record of session tree entry and time/date	***Costsess.log***
VII. Error log for record of problems	***Error.log***
VIII. Other files for session enhancement	
A. Introduction audio	**Cosintro.wav**
B. Graphics path audio instructions	**Cosgrafix.wav**
C. This document in Hyper-Link	**Cosout.hpw or sam**
D. Computer file listing with topic Index	**Filelist.hpw or sam**
E. Contents for use in Hyper-Link	**Cos_eff.hpw**

Files List for Cost Effectiveness Training

Identical information is usually (except where noted) to be found in files with suffix extension of (txt), (hpw), (bmp), (wmf), or (ppt). For example (cos2ratl) may have either a txt, hpw, or ppt. While the format of an hpw file is different from that of a txt file, the information context will be the same.

Text and Hyper-Link Files

COST.TXT, or HPW for all files below - **Entire document** for Cost Effectiveness

COS_OBJ.TXT, or HPW	-p 1	Learning Objectives
COS2RATL.TXT, or HPW	-p 1	Rational
COST3INT.TXT, or etc.	-pp 2-3	Introduction
COS4TRAN.TXT	-pp 4-14	Training Cost **(part 1)**
COS5TRA1.TXT	-pp 4-5	When to measure cost effectiveness
COS6TRA2.TXT	-pp 5-14	Calculating the cost of training
COS6EX1.TXT	-p 6	Ex. of total compensation package
COS6EX2.TXT	-p 7	Ex. of trainee costs
COS6EX3.TXT	-p 7	Ex. of instructor costs
COS6EX4.TXT	-p 8	Ex. of training development and instructional materials preparation costs
COS6EX5.TXT	-p 9	Ex. of instructional materials costs
COS6EX6.TXT	-p 10	Ex. of rented equipment costs
COS6EX7.TXT	-p 11	Ex. of purchased equipment costs
COS6EX8.TXT	-p 12	Ex. of facilities costs
COS6EX9.TXT	-p 13	Ex. of travel and perdiem costs
COS6EX10.TXT	-p 14	Ex. of full cost of training calculation
COS7TRAT.TXT	-pp 15-17	**Progress Check (part 1)** Train. Cost
COS8EFF.TXT	-pp 18-20	Training Effectiveness **(part 2)**
COS8MCE.TXT	-p 20	Looking toward part 3
COS9EFFT.TXT	-p 21	**Progress Check** (part 2) Training Effectiveness.
COS10MCE.TXT	-pp 22-42	Methods, Cost Effectiveness **(part 3)**
COS10ROI.TXT	-pp 22-25	Return on Investment
COS10FLA.TXT	-p23	**Formula** - ROI
COSEXROI.TXT	-p 24	**Example** - of ROI
COS11ROI.TXT	-p 26	**Progress Check** - Return on Invest. (ROI)
COS12CBR.TXT	-pp 27-29	Cost-Benefit Ratio (CBR)

COS12FLA.TXT	-p 27	**Formula** - Cost-Benefit Ratio
COSEXCBR.TXT	-p 28	**Example** - of Cost-Benefit Ratio
COS13BRT.TXT	-p 30	**Progress Check** - Cost-Benefit Ratio
COS14BL.TXT	-pp 31-34	Bottom Line Evaluation
COS14FLA.TXT	-p 31	**Formula** - Bottom-Line Evaluation
COSEXBLE.TXT	-p 33	**Example** - of Bottom-Line Evaluation
COS15BLT.TXT	-pp 35-36	**Progress Check** - Bottom Line Evaluation
COS16PB.TXT	-pp 38-41	Payback Period
Cos16FLA.TXT	-p 37	**Formula** - Payback Period
COSEXPB.TXT	-p 38	**Example** - of Payback Period
COS17PBT.TXT	-p 42	**Progress Check** Payback Period
COSTABLE.TXT	-pp 40-41	**Table** - Advantages and Disadvantages of Methods
COSTEXSC.TXT	-pp 43-48	**Practical Example Skill Check**
COSTREF.TXT	-p 49	References
COSTFDBK.TXT	-pp 50-57	**Progress Check Feedback**

Power Point -- .PPT files

COS1OBJ.PPT	-p 1	Learning Objectives
COS2RATL.PPT	-p 1	Rational
COST3INT.PPT	-pp 2-3	Introduction
COS4TRAN.PPT	-pp 4-14	Training Cost **(part 1)**
COS5TRA1.PPT	-pp 4-5	When to measure cost effectiveness
COS6TRA2.PPT	-pp 5-14	Calculating the cost of training
COS8EFF.PPT	-pp 18-20	Training Effectiveness **(part 2)**
COS8MCE.PPT	-p 20	Looking toward part 3
COS10MCE.PPT	-pp 22-42	Methods, Cost Effectiveness **(part 3)**
COS10ROI.PPT	-pp 22-25	Return on Investment
COS12CBR.PPT	-pp 27-29	Cost-Benefit Ratio (CBR)
COS14BL.PPT	-pp 31-34	Bottom Line Evaluation
COSEXBLE.PPT	-p 33	**Example** - of Bottom-Line Evaluation
COS16PB.PPT	-pp 38-41	Payback Period
COSTABLE.PPT	-pp 40-41	**Table** - Advantages and Disadvantages of Methods

Graphic Bitmap -- .BMP Files

CREDIT.BMP	-	Credit Screen Graphic – Pre-welcome
COST.BMP	-	**Presentation Graphic** – welcome hot spot for – Cost Effectiveness is not .txt et.al (files by the same name)
GENINF.BMP	-	Graphic Screen for objectives, rational & introduction (is not from the .txt files).
COS6EX1.BMP	-p 6	Ex. of total compensation package
COS6EX2.BMP	-p 7	Ex. of trainee costs
COS6EX3.BMP	-p 7	Ex. of instructor costs
COS6EX4.BMP	-p 8	Ex. of training development and instructional materials preparation costs
COS6EX5.BMP	-p 9	Ex. of instructional materials costs
COS6EX6.BMP	-p 10	Ex. of rented equipment costs
COS6EX7.BMP	-p 11	Ex. of purchased equipment costs
COS6EX8.BMP	-p 12	Ex. of facilities costs
COS6EX9.BMP	-p 13	Ex. of travel and perdiem costs
COS6EX10.BMP	-p 14	Ex. of full cost of training calculation
COS10FLA.BMP	-p23	**Formula** - ROI
COSEXROI.BMP	-p 24	**Example** - of ROI
COS12FLA.BMP	-p 27	**Formula** - Cost-Benefit Ratio
COSEXCBR.BMP	-p 28	**Example** - of Cost-Benefit Ratio
COS14FLA.BMP	-p 31	**Formula** - Bottom-Line Evaluation
Cos16FLA.BMP	-p 37	**Formula** - Payback Period
COSEXPB.BMP	-p 38	**Example** - of Payback Period
COSTABL1.BMP	-pp 40-41	**Table** -Advantages and Disadvantages of Methods for Return on Investment
COSTABL2.BMP	-pp 40-41	**Table** -Advantages and Disadvantages of Methods for Cost-benefit ratio
COSTABL3.BMP	-pp 40-41	**Table** -Advantages and Disadvantages of Methods for Bottom-line evaluation
COSTABL4.BMP	-pp 40-41	**Table** -Advantages and Disadvantages of Methods for Payback Period

Audio Media .WAV Files

COSINTRO.WAV	-	Welcome & instructions
COSGRAFX.WAV	-	Objectives, Rational, and Introduction audio with instruction

Emerald Empower and Builder Files

COST.SES	-	Save Session and Restore Session file for auto-rewind
COST_.SES	-	Save Session and Restore Session file for Objectives, Rational, & Introduction
COST1.SES	-	Save Session and Restore Session file for Part 1
COST2.SES	-	Save Session and Restore Session file for Part 2
COST3.SES	-	Save Session and Restore Session file for Part 3
COSTSESS.LOG	-	Log file for record of session tree entry and time/date
ERROR.LOG	-	Error log for record of problems

Other Files for Session Enhancement

COSINTRO.WAV	-	Introduction audio
COSGRAFIX.WAV	-	Graphics path audio instructions
COSOUT.HPW	-	This document in Hyper-Link
FILELIST.HPW	-	Computer file listing with topic: Index
COS_EFF.HPW	-	Contents for use in Hyper-Link

Vita

VITA

Ronald Herbert Gibson was born in Asheville, North Carolina on October 3, 1947. He attended school in the Asheville, Buncombe County school system and graduated from Lee Edwards High School in June 1965. The following fall he entered Asheville Biltmore College (now known as The University of North Carolina, Asheville). He was there until the fall, 1968 when he entered the United States Navy, where he served as an Aviation Electricians' Mate 2nd Class until November, 1972. In June, 1973 he entered Clemson University and in June, 1975 received the degree of Bachelor of Science in Industrial Vocational Education, and in August, 1976 he received a Master of Industrial Education. Between 1976 and 1992 he was Electronics Instructor at Central Missouri State University, an Electrical Contractor, Foreman at Pittsburgh Corning Inc., Senior Electrical Engineer with Becton Dickinson Inc., and Senior Project Engineer at Schlegel North America. In August of 1992 he entered the graduate school at The University of Tennessee, Knoxville, began an Internship in Training at Oak Ridge National Labs, and December of 1999 he received Ph.D. in Human Resource Development.

He is presently The Head of Industrial Technology at Walters State Community College, Morristown, Tennessee.