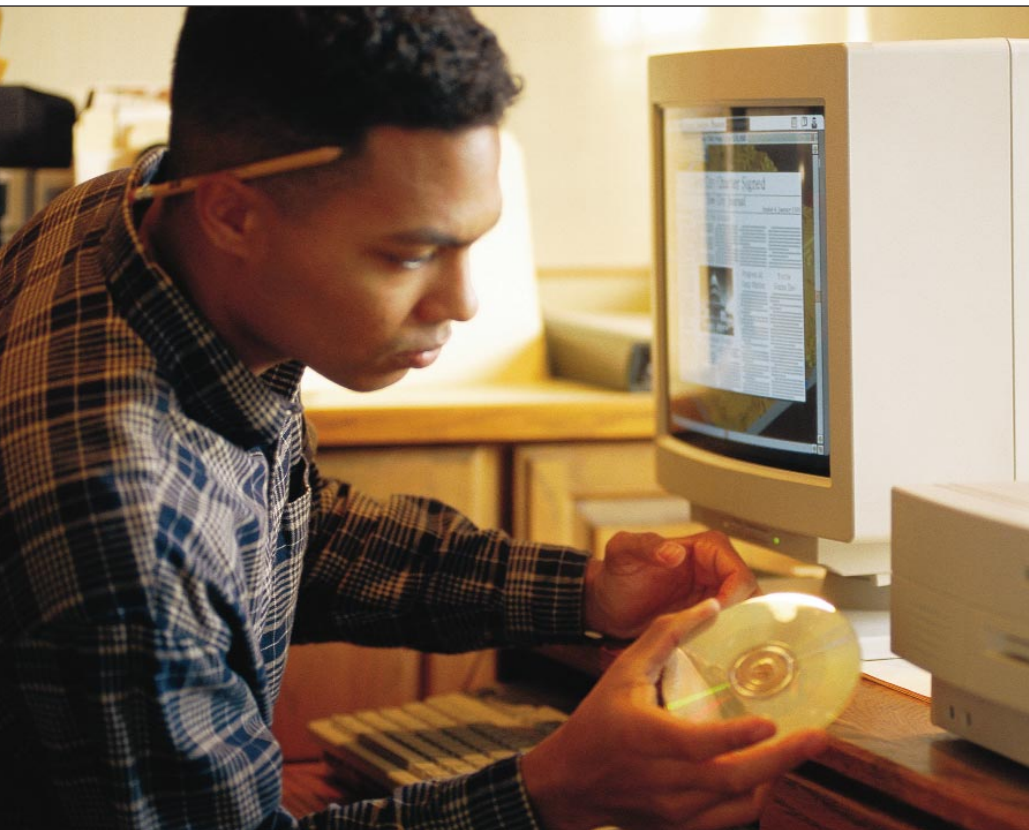


Computer-Based Training: New Technologies for Improved Effectiveness



This article reviews a number of attributes of computer-based training (CBT) for HVAC and suggests some methods for evaluating the best training approach for your firm's needs

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There is a growing demand for training in the HVAC industry in response to the increasing need for better performance of HVAC systems and a reduced number of academic programs teaching HVAC. There are some exciting new developments in the use of computer-based training (CBT) that are increasing the effectiveness of training significantly.

These developments promise to increase the value of training and reduce its cost. This article reviews a number of the attributes of CBT for HVAC and suggests some methods for evaluating the best training approach for your firm's needs.

INCREASING DEMAND FOR TRAINING

Currently, there are multiple factors in the HVAC industry that are increasing the demand for training of all participants in the HVAC delivery process, including engineers/designers, contractors, technicians, and

building operators. Some of these include the following:

- **Certification of HVAC technicians and of building operators** —

The industry-wide adoption of certification of HVAC service technicians as a goal for the industry over the next few years will require the participation in training of more than 400,000 HVAC technicians nationwide. Likewise, the Building Operators Certification program developed by the Northwest Energy Efficiency Council (NEEC) combines a training program with certification.

- **Increasingly complex buildings**

and systems — HVAC systems and equipment (including controls) are becoming more sophisticated and complex, leading to a need for better technical understanding of their nuances by all parties.

• **Utility deregulation leading to more complex operating scenarios** — As utility deregulation becomes a fact across the nation, the need for more sophisticated operating strategies to take advantage of the new utility pricing structures will generate a need for training.

• **Demand for better performance of buildings** — Owners and tenants in buildings are demanding improved indoor environmental quality (IEQ), and HVAC systems are central to good IEQ in terms of improved indoor air quality (IAQ), thermal comfort, and user control. This emphasis on performance will require training and feedback on how better performance is measured and how to achieve it.

• **Retirement of a generation of technicians** — The generations of plant engineers who learned their trade in the armed forces during the 40s, 50s, and 60s are now retiring, leaving a major gap in the ranks that will require training to fill.

• **Reduced number of HVAC engineering programs** — There are fewer HVAC-oriented academic engineering programs at U.S. colleges and uni-

versities than there have been in several decades, so the incoming stream of new engineering graduates into the HVAC industry need HVAC-specific training.

• **Integrated design trend leading to increased need for other disciplines to understand basics of HVAC** — The trend to “integrated design” or “whole-building design” raises the need for the non-HVAC disciplines, such as architects and general contractors, to have a working understanding of the fundamental issues and constraints on HVAC systems.

THE VALUE OF TRAINING

Training helps meet the market needs and trends outlined above, and the training has value in its own right in terms of the impacts that it has, including:

- Overcoming manpower shortages
- Improving building performance economics (reduced costs, increased occupant performance)
- Reducing dependence upon vendor support for training
- Reducing liability claims for poor design, construction, or operation
- Improved productivity and efficiency of the design process, leading to increased profits
- Increased professionalism in the HVAC industry.

Some of these are hard to quantify, and others are easy.

TYPES OF TRAINING

There are a number of different formats and forums for training, including the following:

- On-the-job training (OJT)/apprenticeship
- In-class-focused course (focused time frame)
- In-class course (taken over time)
- Correspondence course
- Distance-learning satellite course
- Video instruction
- Computer-based training (CBT): CD-ROM or Web-based.

The OJT/apprenticeship form represents the “ideal” form of training (from the learning perspective) in many ways: it is “hands on,” “reality based,” and “one on one” between instructor and trainee. The problems are that it takes a long time and it is expensive, inconsistent in content and format, and inflexible relative to the trainee’s schedule and needs. In contrast, most other training formats are a “one-to-many” instructor-to-student model in which it virtually is impossible to tune the pace and level of instruction to the needs of every student. Generally, the pace is aimed at the middle of the class, leaving behind the lower portion of the class and boring the upper portion. Even corre-

TABLE 1. Comparative ratings of various types of training.

| | EFFECTIVENESS | COST | COMPREHENSION | RETENTION | CONSISTENCY | TIME REQUIRED | FLEXIBILITY |
|---|---------------|------|---------------|-----------|-------------|---------------|-------------|
| OJT/apprenticeship | 1 | 5 | 1 | 1 | 4 | 5 | 5 |
| In-class: focused course (focused time frame) | 5 | 3 | 5 | 5 | 3 | 2 | 3 |
| In-class course (over time) | 4 | 3 | 4 | 4 | 4 | 4 | 5 |
| Correspondence course | 4 | 3 | 4 | 5 | 1 | 3 | 2 |
| Distance learning satellite instruction | 3 | 3 | 3 | 3 | 3 | 3 | 5 |
| Video instruction | 4 | 2 | 4 | 4 | 2 | 4 | 2 |
| CBT | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

Legend: 1 = Best possible, 5 = Worst possible.

Note: the above ratings are the author’s subjective opinion, based upon research and reviews.

spondence courses suffer from this because the materials are aimed at a single level that may not be that of the individual trainee.

The technology of CBT offers an unusual opportunity to overcome the disadvantages of each of the other methods. It can, with the right instructional design, emulate the “one-on-one” teaching style of OJT, while providing a very interactive, reality-based learning experience. It is much more cost-effective and flexible than OJT and also can provide a consistency of content to assure that each trainee has a mastery of the subject matter. CBT can be designed to modify the level and pace of the instructional materials to reflect the needs of each trainee, so each should receive a training experience that is customized to their individual needs. Finally, it provides a unique capability to refresh the materials on an as-needed basis during subsequent work experience and to utilize the CBT as a “performance-support system” during actual work.

PROS AND CONS OF VARIOUS TYPES OF TRAINING

Each of these types of training has its advantages and disadvantages, which are summarized in Table 1.

WHAT IS CBT?

CBT is training in which the delivery vehicle is interactive software running on a PC (either from a CD-ROM or an Internet Web browser). The software is designed to permit students/trainees to proceed through the material at their own pace and to be tested for comprehension of the material on a continuing basis. As they demonstrate mastery of the course materials at some specified level of comprehension, they can continue forward through the course topics. CBT courseware is typically designed to function either as a reference tool (in which trainees can select the topics they wish to cover) or as a set-content course in which students must take all topics and pass tests on the material. Beyond these basic elements, the types and forms of CBT vary widely.

TABLE 2.
Economics of CBT in comparison to off-site training.

| | OFF-SITE COURSE | CBT COURSE | OTHER COURSE |
|---|-----------------|------------|--------------|
| Length of Course (Hours for Given Amount of Course Material) | 40 | 32 | |
| COST: | | | |
| Cost of course | \$1000 | \$600 | |
| Cost of travel | \$1000 | --- | |
| Cost of trainee's time (excl. travel) | \$1200 | \$960 | |
| Cost of trainee's time (travel only) | \$240 | --- | |
| Total direct cost for training: | \$3,440 | \$1,560 | \$--- |
| VALUE: | | | |
| Comprehension, percent | 50 % | 80 % | |
| Retention, percent | 40 % | 60 % | |
| Effectiveness ratio (comprehension x retention) | 20 % | 48 % | 0 % |
| Net effective cost (direct cost/effectiveness ratio) | \$17,200 | \$3250 | \$--- |
| Net effective hourly cost (net effective cost/hours of course length) | \$430 | \$102 | \$--- |
| Assumptions: | | | |
| 40-hr course. Assume remote off-site training requiring a week's travel. | | | |
| Assumed \$/hour for trainee's time. | 30 | | |
| Assumed number of travel hours to and from course | 8 | 0 | |

ADVANTAGES OF CBT

Some of the comparative advantages of CBT over other training forms are evident from Table 1. The list below provides a more complete summary of the advantages of CBT:

- Available on demand (any time, anywhere, with subject selectivity)
- Ability to review the materials later at the same level of instruction as original training sessions, but reflecting what the student has learned since the last time
- Responsive to different learning styles (audio, visual, kinesthetic, etc.)
- Consistency of training presentation quality and content
- Ability to update course materials more quickly (particularly with Internet-based courses)
- Takes less time to teach the same material
- More motivational (pace not reduced to slowest learner in class)
- No cost-effectiveness constraint on

small numbers of learners (no minimum class size)

- Easier, more accurate, and immediate assessment of student performance/comprehension.

These advantages have been shown to produce significant improvements in comprehension and retention while also permitting a reduction in training times compared to other methods. Some data supporting this includes the following:

- In 1990, the Institute for Defense Analysis found that multimedia training takes 31 percent less time than equivalent classroom instruction.¹
- In a study by author Gregory Adams, interactive learning took 38 to 70 percent less time than regular training. Adams studied six controlled environments that compared traditional class-

¹Superscript numerals indicate references listed at end of article.

room instruction to equivalent multimedia instruction.²

ECONOMICS OF TRAINING

The economics of training can be evaluated in terms of cost or value. The cost approach computes the total cost of taking the training course, including the tuition or registration cost of the course, and the cost of time spent for the training and travel. Table 2 compares the cost for a typical 40-hr off-site training course with the corresponding costs for a CBT course. There is also a blank column for use in evaluating other courses yourself. It can be seen that the straight out-of-pocket cost for CBT is less than half that for the corresponding off-site course, without regard to the quality of the learning experience.

The value of the training is evaluated in terms of the effectiveness of the training process in transferring usable knowledge and understanding to the trainee. This involves both initial comprehension and subsequent retention of the course materials. The net effectiveness is computed as the product of the comprehension times the retention (since even if the material is initially comprehended, it is only subsequently useful if it can be recalled and applied). Thus, it can be seen from Table 1 that for the comparison, the effectiveness of the off-site course is less than half that of the CBT course.

Combining the cost and value aspects, the overall net effective cost of the off-site course is five times that of the CBT course! The ratio of the net effective hourly costs is only 4 to 1 because the CBT course takes 20 percent fewer hours to convey the same material.

WHY DOES CBT WORK BETTER?

One of the most intriguing aspects of CBT is to explore why it can work so much better than other forms of training. A brief discussion of this will focus on the two principal issues of comprehension and retention. The comprehension issue is an outcome of several factors that none of the other forms of training have (except OJT): increased interactivity, choice of learning styles,

and choice of venue (time, location). The interactivity forces the student to pay attention and allows the student to control the rate and level at which the course material is delivered. [How often have you sat in a class and wished you could fast forward the teacher past a topic you already know or slow him down when you're having trouble?]. By also being able to select varying forms of media (video, audio, text, animations, graphs, equations, etc), students can receive the material in the most meaningful form for their individual learning styles. This greatly facilitates students' comprehension and, as a result, can also reduce the time it takes to move through the course material.

Improved retention is also a direct outgrowth of many of these same factors. If the students are active participants in formulating the learning approach, they are motivated more and likely to retain the course materials covered. The frequent testing for mastery of the materials, which helps students to identify areas that they need to work on while also informing the CBT tool so that it can reinforce the topic areas needing it, also reinforces this.

CHARACTERISTICS OF GOOD CBT

The discussion above treats all CBT as generically equivalent, which is not true. The summary of positive attributes and outcomes ascribed above to CBT is based upon the presumption that the CBT incorporates the best features and avoids the worst shortcomings of the range of CBT products. Having reviewed and tested over 100 CBT programs over the past five years, the author can attest to the fact that this is a simplistic assumption. There are in fact many products that do not have the best and which do commit some of the worst, and this discussion is designed to provide some guidance in the evaluation of potential CBT programs.

What are the characteristics of the best types of CBT?

- Interactive, requiring students to take actions that depend upon comprehension

- Adaptive, adjusting the rate and/or level of training presentation to the student's comprehension

- Simulates real-world situations and demands problem solving, applying the learned principles

- Uses an instructional design that allows the student to drill down into a topic more deeply, if interested

- Utilizes a broad range of stimuli (animation, video, audio, text, graphs, hot spots) to enrich the presentation and appeal to varying interests of students

- Provides reliable/credible information from a trusted source.

What are some of the worst features of CBT to be avoided, if possible?

- Uses "talking heads" videos of instructors speaking the material (as opposed to showing and demonstrating the material itself)

- Uses simplistic graphics that don't enable the student to correlate the concepts with real-world applications or examples.

Of course, the most important feature is the content of the CBT course. Review it to make sure it is what the trainee needs to learn.

CONCLUSION

There is increased need for training in the HVAC industry in response to a number of industry trends and needs. Computer-based training (CBT) is the best choice for cost-effective training that can enhance comprehension and retention of the subject matter. There are many ways in which good CBT can provide an improved learning experience over other forms of training. Not all CBT is created equal, and it is important to evaluate the CBT products you are considering for the key factors that are critical to an effective CBT experience. HPAC

REFERENCES

- 1) Institute for Defense Analysis, "ROI of CBT," *CD-ROM Professional*, October 1996.
- 2) Adams, Gregory, "Why Interactive," *Multimedia & Videodisc Monitor*, March 1992.

Circle 508 on reader service card if this article was useful; circle 509 if it was not.