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DISCUSSION ARTICLE

Effectiveness of Interactive Computer-Based Instruction: A Review of Studies Published Between 1995 and 2007

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Computer-based instruction (CBI) has been growing rapidly as a training tool in organizational settings, but close attention to behavioral factors has often been neglected. CBI represents a promising instructional advancement over current training methods. This review article summarizes 12 years of comparative research in interactive computer-based instruction relevant to employee training techniques. The results demonstrate that CBI is an effective and viable training technique, and several areas in need of further examination are detailed.

KEYWORDS computer-based instruction, interactive, training

Training has always played an important role for business and industry. This importance is demonstrated by employer expenditures, with investments that reach $55 billion in formal training programs and $180 billion in informal on-the-job training yearly (Schultz & Schultz, 2006). As job procedures change due to technological innovations, the need for effective training is becoming increasingly important. Business owners and managers are in need of cost-efficient and high-quality training methods to keep up with the demand for skilled labor.

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Organizational behavior management (OBM) does not appear to be keeping up with this demand. A glimpse at some of the most popular OBM books indicates that chapters on training / instruction or any other coverage of the topic are absent (Braksick, 2000; Daniels & Daniels, 2004). An informal review of articles published in the *Journal of Organizational Behavior Management* during a five-year period reveals a similar trend. Of the 65 articles (excluding book reviews) published between 2003 and 2007, only four (Hickman & Geller, 2003; Pampino, Wilder, & Binder, 2005; Rohlman et al., 2004; Sasson & Austin, 2004) appear to cover training in any depth beyond task clarification. Furthermore, only two (Pampino et al.; Rohlman et al.) appear to involve training solutions more in-depth than "training as usual" (i.e., simply giving trainees a manual or lecture). Thus, out of 65 articles, only about 3% cover sophisticated behavioral training methodologies.

This area represents an important opportunity for OBM practitioners to deliver a product that is highly requested by the business community, which can then be possibly followed by practitioners selling more behavioral solutions for other business problems and needs (that may be less requested but just as needed). Considering the importance of training methods to managers, the topic appears underrepresented and therefore more research is called for. Indeed, the topic rarely receives any attention beyond a very superficial coverage relating to task clarification. Perhaps this is because instruction and training are often viewed as just antecedents to behavior, and OBM aims to utilize the more powerful variable of consequences to influence behavior. From a molecular point of view, instruction and training do not need to be just antecedent events but can also include behaviors and consequences, as exemplified by Direct Instruction, Personalized System of Instruction (PSI), and Precision Teaching (Fox, 2004; Maloney, 1998; Slocum, 2004). However, most who argue that training is just an antecedent are probably taking a molar view. That is, they are taking a more broad view and see training overall (including all the relevant training antecedents, behaviors, and consequences) as an antecedent to on-the-job performance, which should be followed by workplace consequences. While it is also true that training is likely to be ineffective and have no long-term impact without being followed up with on-the-job consequences, that is no reason to equate training as being unimportant. Regardless of whether you are taking a molecular view or molar view, training remains a very important part of the workplace process, and behavior analysts would do well not to be dismissive of it. Given that behavior analysts often consider themselves experts on the learning process, it is surprising that there is a paucity of research on training and instruction within OBM. While there are exceptions such as Accelerated Learning and Performance-Based Instruction (Brethower & Smalley, 1998; Bruce, 2004; Daniels, 2000), the topic still remains underrepresented.

Despite the lack of research on training and instruction, the applied world has not forgotten about the topic. For leaders of business and industry, an increasingly common solution to meet the needs of training is computer-based instruction (CBI). Oblinger and Rush (2003) state that the corporate e-learning market was expected to exceed $23 billion by 2004, demonstrating a 68.8% annual growth since 1999. Part of the popularity of CBI may be due to its flexibility. There is no need to wait until the number of trainees grows large enough to fill a classroom or wait until a suitable trainer can be located. CBI can easily accommodate geographically diverse locations and appears to reduce the amount of time dedicated to training (Schultz & Schultz, 2006). Despite its popularity, caution should be urged, as popularity does not equate with effectiveness. When designing CBI, a number of variables need to be considered.

First of all, instruction should enforce active engagement, a critical variable echoed by many others (Markle, 1990; Molenda & Russell, 2006; Skinner, 1954, 1958). Instruction should be learner paced, proceeding only when the learner is ready, a feature also implemented by other effective behavioral teaching approaches such as PSI (Fox, 2004). Further, effective instruction should include mastery criteria to ensure a learner demonstrates mastery of material prior to being allowed to progress to subsequent material, much like Direct Instruction, PSI, or an effective tutor (Slocum, 2004). Effective instruction should also include immediate feedback to strengthen desired responses and correct undesired responses.

For the purposes of the article, training and education will be treated as similar activities, subsumed under the more generic label of instruction. The critical attribute of instruction (as well as education and training) is that it is aimed at producing learning (Molenda & Russell, 2006). Computer-based instruction can solve many of the problems of traditional instructional methods. For example, lectures and workshops are typical instructional methods, but are problematic because they are instructor paced, and group instruction tends to be geared toward the average learner. Therefore, advanced learners are left bored and anxious to move on, while slower learners are confused and left behind. Some instructional approaches such as Direct Instruction attempt to overcome this problem by using placement tests to form homogeneous groups in an attempt to ensure that everyone in the group is an average learner (Slocum, 2004). The feasibility of adapting this for the business world of adult learners is questionable. Learners are more likely to have very diverse repertoires, making the formation of homogeneous groups much more difficult. Furthermore, multiple groups suggest multiple trainers, which may not be practical. Computer-based instruction can avoid this difficulty of group instruction by individualizing the instructional pace for each trainee. As long as computers are available, large-scale implementation with large numbers of trainees is possible, yet training can still remain learner paced.

Textbooks and training manuals are also typical instructional methods. Such textual materials have the advantage of being learner paced in that trainees don't need to turn a page until they are ready. However, they have a problem in that they can't enforce active responding. Textual materials can include study objectives, review questions, frequent response requests, and other similar attempts at interaction, but trainees can easily bypass such requests with no immediate consequence. No matter how carefully hidden an answer is, there is always the probability that all but the most self-disciplined learners will peek at answers prior to making a response (Markle, 1990). Furthermore, even if a response is made, textual material offers no programmed differential consequences. CBI programs can be designed so that progression in the instructional material is prevented until learners make an appropriate response. Thus, CBI can enforce interactions.

One-on-one trainers come closest to being the most viable effective training solution. Unlike group instruction, the pace can be tailored to the individual student. Unlike books, active responding can be enforced. Unfortunately, one-on-one trainers can be cost prohibitive and impractical. Computer-based instruction is much like a one-on-one trainer, except many of the associated costs are avoided. One of the biggest advantages of CBI is the possibility of enforced and economical interactions.

Many current CBI programs claim to be interactive, but a closer look at them can reveal problems with their definition of interactive. Interactive sometimes only means that the learner has control over the pace and sequencing of materials. This level of interaction is no more advanced than a textbook, given that textbooks also allow learners to turn pages when ready and to skip around between chapters. In general, CBI programs have failed to revolutionize instruction because most have been designed to replicate traditional instruction, thus they often produce the same results (Engelmann, 1992; Skinner, 1963). Instruction should be designed to promote responses that are more meaningful than those required by a simple digital textbook (Markle, 1990). Interactions should be demonstrative, requiring the learner to show they understand a given point before proceeding to new material. The possibility of allowing economical, enforced, and demonstrative interactions is the one unique offering of CBI, one that distinguishes it from other instructional alternatives. For brevity's sake, CBI that is economical, enforced, and demonstrative in its interactions will simply be referred to as "interactive CBI" for the remainder of the article. The main purpose of this review is to examine if interactive CBI truly is more effective than other training formats and if so, what are the most effective forms of interactive CBI. The best practices described by this article should aid managers, consultants, and training developers to select and create the most effective training solutions. Furthermore, by discovering what is currently known about interactive CBI, it is hoped the stage will be set for investigating what we don't know in future studies.

Although much of CBI research focuses on inferred behaviors/processes and variables outside the control of a programmer or instructional designer (e.g., schema formation, self-directedness), this article will review only interactive CBI research investigating variables that could be controlled by an instructional designer (e.g., feedback inclusion, response requirements). Part of the reason is to operationally define concepts that will allow for replication, but the main concern relates to the pragmatics of improving instruction. For example, discovering that CBI is more effective with self-directed learners tells instructional designers, computer programmers, and training developers little about how they should alter CBI. Instead, such individuals are simply left to hope that the recipients of their products just happen to be self-directed learners.

Much of CBI research is also problematic in terms of the measures employed. Social validation is often used as the sole measure of success. While learner preference is certainly an important consideration, it should not be the only measure used to evaluate success. Again, popularity does not necessarily equate with effectiveness. Given that organizations are concerned with how training will improve organizational performance, this article will only survey those CBI studies that included an objective measure of performance.

Many of the research designs used are problematic as well. Typical designs include the one-group pretest-posttest design and the untreated control group design (Shadish, Cook, & Campbell, 2002). The one-group pretest-posttest design involves assessing learner knowledge with a pretest, administering a CBI program, and then assessing learner knowledge again with a posttest. Effectiveness of the CBI program is evaluated by comparing the pretest scores (no instruction condition) with the posttest scores (having received instruction condition). The untreated control group design involves two groups. The first group receives CBI and the second group receives no instruction. Both groups are then given a test to assess their knowledge. Similar to the previous design, effectiveness of the CBI program is evaluated by comparing the control group scores (no instruction condition) with the CBI group scores (having received instruction condition). Ultimately, the outcomes of these designs only tell us if CBI is better than nothing at all, a less than awe-inspiring standard. These designs tell us little about the relative effectiveness of CBI compared to other instructional approaches, which does not help those in charge of training choose the most effective solutions. Thus, this review will only examine comparative research involving interactive CBI. The comparative evaluations will be between interactive CBI and another type of instruction such as an alternative interactive CBI, noninteractive CBI, or non-CBI instruction.

To increase the likelihood of this study's outcomes being relevant to the managers, supervisors, and training developers, only studies involving employees or employee analogs (normal, adult learners) will be considered.

Part of the reason for excluding CBI studies with children is that differences in verbal sophistication might imply differential effects of experimental variables. For similar reasons, CBI studies where the subject matter involves a foreign language will also be excluded.

METHOD

Search Procedures

The Psychological Information (PsycINFO) database was used to identify peer-reviewed journal articles on interactive computer-based training/ teaching between the years of 1995 and 2007. The following subject phrases were used to identify articles: computer assisted instruction, computer training, teaching machines, and computer assisted diagnosis. The following keywords were also used to identify additional articles: Web-based training, Web based training, Web-based instruction, Web based instruction, computer-based training, computer based training, computer-based instruction, computer based instruction, computer-aided training, computer aided training, computer-aided instruction, computer aided instruction, computer-assisted training, computer assisted training, computer-assisted instruction, computer assisted instruction, computer training, multimedia instruction, multimedia training, Internet instruction, Internet training, and computer instruction. These searches yielded a total of 3,970 articles.

Initial Inclusion

The abstracts of the 3,970 articles were read in an attempt to exclude nonrelevant articles. The first and second authors independently reviewed 100% of the abstracts. Articles were excluded on the following grounds: participants were selected from "abnormal" populations, such as DSM-IV diagnosed clients; participants were nonadults (under 18 years of age); participants were developmentally disabled; instructional content involved language skills acquisition, such as computer assisted language learning (CALL); articles that were reviews of books or book chapters; or articles that were theoretical in nature with no empirical data. Articles were also excluded if they only studied variables beyond the control of an instructional designer, such as self-directedness of learners, locus of control, etc. Articles were included if they involved comparative investigations of interactive computer-based training/teaching with normal, adult learners. The empirical comparisons could be between interactive CBI and another form of instruction, including alternative interactive CBI methods, noninteractive CBI, or instruction that wasn't computer-based. A CBI program would be considered interactive if it required the learner to demonstrate understanding of the material during the learning process (i.e., answer questions while learning the material prior to final performance outcome measures). A CBI program would be considered noninteractive if learners were not required to demonstrate understanding of the material during the learning process (e.g., only viewed a simulation, only clicked a next button, etc). To be included, articles had to include objective measures of performance outcomes. Finally, the articles had to investigate variables that could potentially be controlled by an instructional designer, such as the pace of the program, type of feedback, etc. Interobserver agreement (IOA) was calculated for the abstracts reviewed by both authors (agreements divided by agreements plus disagreements). There was a 90.1% agreement between authors for initial inclusion. Articles were only excluded if both the first and second authors independently agreed they should be excluded, so that all disagreements resulted in the article being included for a more in-depth analysis than a reading of the abstract (such inclusion of disagreements did not mean an article would be included for the final coding and analysis at this stage). At this stage of inclusion there was a bias toward including articles, and this was done intentionally because it is often very difficult to evaluate an article on the basis of the abstract alone. As a result, 3,059 articles were excluded and 911 articles were retained.

Final Inclusion

The remaining 911 articles were read in detail to determine if they met the inclusion criteria. The first author independently evaluated 100% of the articles to determine their appropriateness for inclusion. The second author independently evaluated a random selection of the articles ($n = 410$) to obtain IOA. There were no disagreements at this stage of inclusion, resulting in IOA reaching 100%. The final count of articles to be included in this review was 71 articles. Some of these articles involved multiple experiments, which were separated out to facilitate analysis. To clarify which specific comparison is being discussed, c1, c2, or c3 (comparison 1, comparison 2, or comparison 3, respectively) will be added after the year citation (e.g., Atkinson, 2002c1, 2002c2; Bodemer, Kazmerski, & Torgerson, 2004c1, 2004c2; Howard-Jones & Martin, 2002c1, 2002c2; Miller & Malott, 1997c1, 1997c2; Moreno & Valdez, 2005c1, 2005c2, 2005c3; Rohlman et al., 2004c1, 2004c2, 2004c3). Thus, a total of 79 experimental comparisons were selected for coding and analysis.

Coding Categories and Definitions

Goal

Interactive CBI for each article was classified as (a) education, (b) training, or (c) life skills. Articles were considered as for “education” if CBI was done as part of an educational curriculum within a higher education setting. The classification of "training" was used if CBI was designed to facilitate performance in currently held jobs. The classification of "life skills" was used for instructional purposes that didn't fit either the education or training classifications (e.g., parenting skills, exercise skills, etc).

Usage

Interactive CBI was classified as either (a) primary or (b) supplemental, depending on whether the CBI was designed to stand alone as the main form of instruction or be used in conjunction with another instructional format.

Pace

The interactive CBI was classified as either (a) machine paced or (b) student paced. CBI was considered "machine" paced if the learner had no control over the speed at which material was presented (with the exception of interactions). For example, if a learner watched an automated sequence of slides in which the program only paused for the learner to make a response, then this was considered machine paced. CBI was considered "student" paced if the instructional material progressed only when a learner allowed (e.g., learner clicks a "next" button).

Mastery criteria

Articles were also classified according to the presence or absence of mastery criteria. An article was classified as utilizing mastery criteria only if the article detailed a system in which learners could not progress to later parts of instructional material prior to demonstrating understanding on previous material by meeting some predetermined criteria. Further, the program had to be designed in some fashion to prevent learners from successfully passing an interaction on their first attempt by blindly selecting answer choices. Otherwise, an article was designated as not including mastery criteria.

Response interaction

Articles were classified as (a) compose, (b) select, (c) mixed, (d), various, or (e) unknown based on the type of response learners were required to make by the interactive CBI program. "Compose" was defined as an interaction type in which a large variety of potential responses could be given, such as typing a response or using a drag-and-drop interaction. "Select" was defined as an interaction type in which learners choose answers from a list of predetermined answer choices (i.e., multiple choice). The "mixed" classification was used for CBI programs that utilized compose and select formats within the same instructional program. The "various" classification was used when an article used multiple programs, some of which used compose and some of which used select (e.g., comparison study of composing versus selecting an answer). Articles were marked as "unknown" when there were insufficient details to classify the response interaction.

Feedback type

Articles were also classified based on the type of feedback used in the interactive CBI: (a) contingent-specific, (b) contingent-nonspecific, (c) noncontingent, (d) none, (e) various, or (f) unknown. "Contingent-specific" was applied to programs in which feedback specifies why learner's responses were correct or incorrect. "Contingent-nonspecific" was used when the CBI program simply stated whether or not the learner's response was right or wrong, with no explanation. The "noncontingent" classification was used for CBI programs that simply stated the correct answer, with no evaluation of the learner's response. "None" was used when feedback was not presented for learner's individual responses during the CBI. "Various" was used when an article used multiple programs that differed in the types of feedback utilized. "Unknown" was applied when there were insufficient details to classify the type of feedback used.

Supplemental incentives

Articles were classified according to the type of external incentive used: (a) performance dependent, (b) performance independent, (c) none, or (d) various. For "performance dependent," rewards or punishers were provided by a source external of the CBI, but the quantity of which depended on how well a learner performed during the interactive CBI program (e.g., losing 5 points for every incorrect answer, receiving $20 for achieving 90% correct or better). "Performance independent" was applied when rewards or punishers were provided by a source external of the CBI and the quantity did not depend on how well the learner performed (e.g., receiving extra credit for participation, receiving $50 for simply completing CBI). When there were no external incentives specified, the label of "none" was applied. "Various" was reserved for studies in which some participants received one type of external incentives and other participants received a different type of external incentives (or lack thereof).

Outcomes

Of the experimental comparisons being made, the instructional approach that proved superior was also assessed. Statistical comparisons of differences between instructional approaches were judged as significant at an alpha level of 0.05 or less.

Coding IOA

Interobserver agreement was calculated based on the classifications of two independent coders. Overall IOA was calculated for the categories of goal, usage, pace, mastery criteria, response interaction, feedback type, supplemental incentives, and outcomes. IOA was calculated using the number of agreements divided by the number of agreements plus disagreements. The resulting IOA score was 95.6%. The disagreements were then analyzed and discussed between coders until an agreement was reached.

RESULTS

Comparisons Between Interactive CBI and Another Instructional Format

The Appendix summarizes the results of the coding classifications. Overall the results favored the use of interactive CBI alone or as a supplement. In the 42 comparisons between instructional formats, 27 demonstrated improvements through the use of interactive CBI (64.3%). Thirteen comparisons found no difference or mixed results (31.0%). Only two comparisons found another instructional format superior to interactive CBI (4.8%). Thus, interactive CBI was found to be at least as good as, if not better, than instructional alternatives 95.2% of the time. See Figure 1 for a summary of these comparisons.

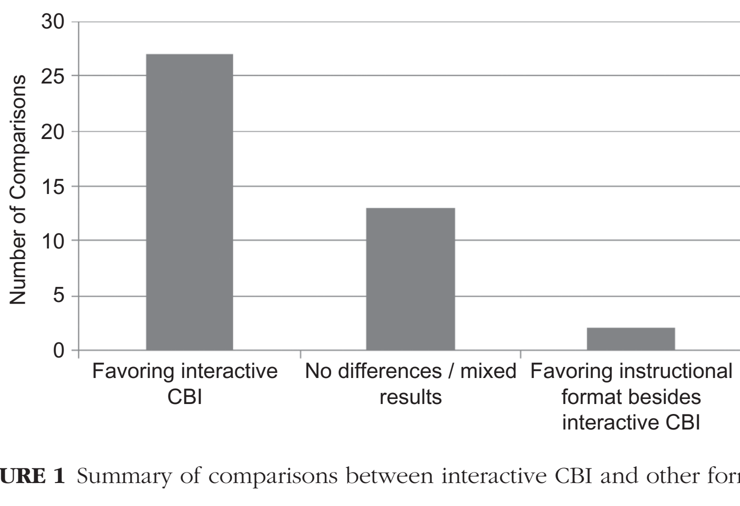

FIGURE 1 Summary of comparisons between interactive CBI and other formats.

Interactive CBI Compared With Noninteractive CBI

There were twenty comparisons that examined interactive CBI and noninteractive CBI (Bodemer, Ploetzner, Feuerlein, & Spada, 2004c1; Bodemer et al., 2004c2; Cook, Gelula, Dupras, & Schwartz, 2007; Darabi, Nelson, & Palanki, 2007; Davis, Bostow, & Heimisson, 2007; Dornisch & Sperling, 2006; Eckerman et al., 2002; Evans & Gibbons, 2007; Howard-Jones & Martin, 2002c1; Howard-Jones & Martin, 2002c2; Katayama & Crooks, 2003; Kerwin, 2006; Kritch & Bostow, 1998; Martin, Klein, & Sullivan, 2007; Miller & Malott, 1997c1; Miller & Malott, 1997c2; Moreno & Valdez, 2005c1; Rohlman et al., 2004c2; Tudor, 1995; Van Rooij, 2007). Fourteen of the twenty comparisons favored interactive CBI over noninteractive CBI. Two comparisons (Howard-Jones & Martin, 2002c1; Kerwin, 2006) favored noninteractive CBI over interactive CBI. One comparison (Moreno & Valdez, 2005c1) found mixed results. Three comparisons (Bodemer et al., 2004c1; Dornisch & Sperling, 2006; Rohlman et al., 2004c2) found no differences.

Interactive CBI Compared With Textual Presentation

There were six comparisons that examined interactive CBI and textual instruction such as textbooks, manuals, and workbooks (Aberson, Berger, Healy, & Romero, 2003; González & Birch, 2000; Luyben, Hipworth, & Pappas, 2003; Morris, 2001; Pelayo-Alvarez, Albert-Ros, Gil-Latorre, & Gutierrez-Sigler, 2000; Rohlman et al., 2004c1). Three comparisons found interactive CBI to be superior. Two studies found no differences between training conditions (González & Birch; Morris). One study found mixed results (Rohlman et al., 2004c1). In that study, interactive CBI was found to be superior to a manual with text-based quizzes and a manual without text-based quizzes. However, no differences were found between interactive CBI and a manual with both text-based quizzes and answers.

Textual/Interactive CBI Hybrid Compared With Textual Instruction Alone

There was one study that examined textual instruction with interactive CBI compared with textual instruction alone (Sholomskas & Carroll, 2006), which found superior performance with the CBI supplement.

Interactive CBI Compared With Video Presentation

Only one study compared interactive CBI to a video presentation (Segal, Chen, Gordon, Kacir, & Gylys, 2003). The study found no differences between teaching methods.

Interactive CBI Compared With Group Oral Presentation

There were 10 comparisons that examined interactive CBI and lecture style instruction (Blasko, Kazmerski, & Torgerson, 2004; Connolly, MacArthur, Stansfield, & McLellan, 2007; Fisher, Deshler, & Schumaker, 1999; Fitzgerald, 1995; Jenny & Fai, 2001; R. H. Maki & W. S. Maki, 2003; R. H. Maki, W. S. Maki, Patterson, & Whittaker, 2000; Orey, Zhao, Fan, & Keenan, 1998; Parchman, Ellis, Christinaz, & Vogel, 2000; Shute, Gawlick-Grendell, Young, & Burnham, 1996). Eight of the ten comparisons demonstrated superior results for interactive CBI. Fisher et al. and Shute et al. were the exceptions, finding no differences.

Lecture/Interactive CBI Hybrid Compared With Lecture Alone

Four studies involved using interactive CBI to supplement lecture and compared such a hybrid with lecture alone (Batchelder & Rachal, 2000; Croninger, Tumiel, & Sowa, 1995; Flora & Logan, 1996; Hahne, Benndorf, Frey, & Herzig, 2005). Two of the four comparisons found that adding an interactive CBI component improved the lecture format. Batchelder & Rachal and Hahne et al. found no differences between the supplemented and nonsupplemented lecture formats.

Comparisons of Different Elements Within Interactive CBI

Pacing

Of the 79 experimental comparisons included in this review, 75 utilized learner pacing (94.9%). The remaining 4 utilized computer controlled pacing (5.1%). None of the studies directly compared the benefits or costs of implementing learner versus computer controlled pacing.

Sequences

There were three comparisons of scripted instructional sequences versus learner controlled sequences (Bell & Kozlowski, 2002; Bodemer et al., 2004c2; Henry, 1995). Two of the comparisons found favorable results when using scripted instructional sequences and one comparison (Henry) found no differences. A study by Green, Eppler, Ironsmith, & Wuensch (2007) compared linear and branching formats. In linear formats, all users are exposed to the same instructional sequences. In branching formats, users who make errors are exposed to additional supplemental material designed to remediate errors. The study found performance superior under the branching format. J. Reisslein, Atkinson, Seeling, & M. Reisslein (2006) compared sequences in which users are first exposed to worked out examples followed by problems, sequences in which users are first exposed to problems followed by worked out examples, and sequences utilizing the fading of hints. No differences were found between instructional sequences. Lusk and Atkinson (2007) examined whether performance would be best when instructional sequences displayed only one step at a time with sequences displaying all steps simultaneously. Performance was superior when only one step was displayed at a time.

Practice

Three studies examined the effects of additional practice items (Schnackenberg & Sullivan, 2000; Shute & Gawlick, 1995; Shute, Gawlick, & Gluck, 1998). While the amounts of practice differed, two of the three studies found that additional practice improved performance. The third study (Shute & Gawlick) found no effects by adding additional practice items. One study looked at the effects of the density of interactions (Whittam, Dwyer, & Leeming, 2004). This differed from amount of practice because the total number of questions remained consistent across conditions (3 questions after every 5 instructional frames, 6 questions after every 10 instructional frames, or 12 questions after every 25 instructional frames). Density of interactions was irrelevant to performance outcomes. Fox and Ghezzi (2003) examined the effects of fluency training with normal practice. No performance differences were found. However, Brothen and Wambach (2004) compared timed quizzes with untimed quizzes and found that imposing a time limit improved performance.

Modality of narrative/prompts

Seven comparisons examined the types of modality by which narration and prompts are delivered (Atkinson, 2002c1, 2002c2; Atkinson, Mayer, & Merrill, 2005; Kalyuga, Chandler, & Sweller, 1999, 2000; Lusk & Atkinson, 2007; S. M. Truman & P. J. Truman, 2006). Four comparisons evaluated narration and prompts delivered via auditory or visual means (Atkinson, 2002c1, 2002c2; Kalyuga et al., 1999; S. M. Truman & P. J. Truman, 2006). All four favored audio narration and prompts. Kalyuga et al. (1999) also included a dual audio/visual condition, but audio only was still superior. Atkinson et al. examined whether instructions should be delivered using a human voice or machine voice and found improved performance when utilizing human voices. Kalyuga et al. looked specifically at the modality of descriptions for diagrams. They found no differences between audio text, visual text, and audio/visual text used to describe on-screen diagrams. Lusk & Atkinson compared animated prompts, static prompts, and no prompts and found superior performance for animated prompts.

Graphics/text

Three comparisons examined the effects of integrating graphics and text or using a split approach (Bodemer et al., 2004c1, 2004c2; Moreno & Valdez, 2005c1). All three found that integrating graphics and text improved performance. Johari (2003) compared CBI with graphs to CBI without graphs and found the inclusion of visuals improved performances. Parchman et al. (2000) found that the inclusion of multimedia elements improved performance over their exclusion. Prestera, Clariana, and Peck (2005) looked at whether matching screen colors of teaching and testing frames would improve retention over mismatches. No differences were found between conditions.

Rules versus learning by examples

Two studies compared CBI utilizing definitional learning (detailed rules) versus exemplar learning (examples/nonexamples). One study found exemplar training to be superior (Fox & Ghezzi, 2003), whereas the other study found no differences (Hopkins, 2002).

Relationship training

One study examined the effect of requiring users to learn concepts through the following methods: by training users to classfiy concepts, training users how concepts are related, a mixture of classification and relationship training, or no training (Fox & Sullivan, 2007). Performance was higher when concept learning utilized classification training only. Another study compared three different methods for presenting information: task information, cognitive information, and functional validity information (Gattie & Bisantz, 2006). Task information involved detailing how information presented is related to the training criteria. Cognitive information involves detailing which cognitive strategies (i.e., rules) should be used. Functional validity information involves emphasizing the relationships between training criteria and rules being used. The outcome of the study found that the task information format would produce the highest results. A study by Munyofu et al. (2007) compared the presentations of animations alone, animation and text mixed together with a focus on the current topic, and animation and text mixed together with a focus on the relationships between topics. Performance was found to be higher when the instruction focused on the relationships between topics.

Postfeedback delays

One study examined inclusion and exclusion of postfeedback delays (Kelly & Crosbie, 1997). Postfeedback delays involve an arrangement where the user's answer and relevant feedback are displayed following a response, and users cannot progress to subsequent material for a set period of time. Postfeedback delays were shown to be beneficial for learning.

Timed CBI

One study (Moreno & Valdez, 2005c2) looked at imposing a time limit for completion of CBI in its entirety (not just practice components) versus no time limits. The study found no differences between conditions.

Open book/closed book interactions

One study looked at the effect of allowing supplemental materials during training interactions (not testing interactions) versus not allowing such material (Rohlman et al., 2004c3). The study found that an open book format produced superior results during testing sessions.

Response requirements

Five comparisons examined the effects of requiring overt responses or requesting covert responses (Bodemer et al., 2004c1, 2004c2; Miller & Malott, 1997c1, 1997c2; Tudor, 1995). Four comparisons found that an overt response requirement resulted in improved performance. One comparison (Bodemer et al., 2004c1) found no differences. Three studies compared the effects of interaction formats that require users to compose a response versus formats that require users to select a response (Clariana, 2003, 2004; Katayama, Shambaugh, & Doctor, 2005). All three studies favored requiring users to compose a response (fill-in-the-blank) rather than select a response (multiple choice). One study compared the effects of requiring users to compose original note summaries versus requiring users to copy and paste text to create notes while using large and small graphical organizers (Crooks, White, & Barnard, 2007). This study found no significant main effects between conditions, although a significant interaction was found. One study examined the effect of required notes to be composed versus making note composition optional (Armel & Shrock, 1996) and found performance was higher when note taking was required.

Multiple pathways versus singular path to correct answer

One study (Yadrick, Regian, Connolly-Gomez, & Robertson-Schule, 1997) examined the differential effects of allowing users different methods of producing a correct answer versus forcing users to duplicate the trained method exactly. Allowing users to employ any method was found to produce the best results.

Effects of feedback

Out of the 79 comparisons, 25 (31.6%) utilized contingent and nonspecific feedback, 18 (22.8%) utilized contingent and specific feedback, 6 (7.6%) utilized noncontingent feedback, and 9 (11.4%) did not utilize feedback. Among the remaining comparisons, 19 lacked sufficient details to identify the type of feedback used and 2 (Green et al., 2007; Morrison, Ross, Gopalakrishnan, & Casey, 1995) used a mixture of feedback types. Only two studies made direct comparisons of feedback approaches (Gibbons, Robertson, & Thompson, 2001; Morrison et al., 1995). Gibbons et al. examined the effects of providing expert feedback with the effects of providing learner feedback. Comparative feedback involved evaluative comparisons between answers learners selected with answers that should have been selected. Learner feedback involved objective summaries of the selections that learners had made. The study found favorable results for providing evaluative feedback (expert commentary) over providing objective feedback (summary of learner performance). The study also compared the effects of single step feedback (what should be learned from a particular step) with linked feedback (what should be learned from a particular step as well as how the step relates to other steps). No differences were found in learner performance.

Morrison et al. (1995) looked at four different feedback formats: knowledge of correct response (KCR), delayed knowledge of correct response (delayed KCR), answer until correct (AUC), and no feedback. KCR involved learners being informed of the correct answer following a response, regardless of the accuracy of the response (noncontingent feedback). The delayed KCR format was identical to KCR, except that feedback was not delivered immediately after the response. With the AUC format, learners would be informed of the answer only after an accurate response (contingent feedback). Both KCR and delayed KCR were found to be superior to AUC and no feedback. However, no differences were found between KCR and delayed KCR.

Mastery learning

Out of the 79 comparisons, 12 (15.2%) included some form of mastery learning. Two of those studies made direct comparisons of mastery learning (Montazemi & Wang, 1995; Moreno & Valdez, 2005c3). Montazemi and Wang compared the inclusion and exclusion of mastery learning criteria and found that the inclusion of mastery improved learning. Moreno and Valdez (2005c3) looked at two different mastery learning formats: one in which learners had to repeat multiple previous steps following an error with one in which learners had to repeat a single previous step following an error. Repetition of multiple previous steps produced better performance than repetition of a single previous step.

INCENTIVES

Out of the 79 comparisons, 21 (26.6%) involved the use of external incentives (rewards and punishers delivered by a source other than the computer assisted instruction). In four of those studies, the incentives were delivered contingent upon specific performance. Seventeen studies involved incentives delivered for just completion of the program and were otherwise independent of specific performance. Two studies (Morrison et al., 1995; Munson & Crosbie, 1998) directly compared the use of performance-dependent and performance-independent incentives. Both studies found that making incentives dependent upon specific performance during learning improved performance.

DISCUSSION

Consistent with previous reviews (J. A. Kulik, 1994; C.-L. C. Kulik & J. A. Kulik, 1991), the overall results found that interactive CBI improved performance. A number of best practices can be recommended based on the findings of this review. Foremost, interactive CBI is an effective and recommended method for delivery of training materials, one that is very likely to produce superior learning outcomes over other approaches such as noninteractive CBI, textbook instruction, and lecture instruction. Even if one does not wish to implement a training approach dependent on CBI alone, supplementing current instructional methods with interactive CBI also appears to improve learner performance. Supervisors and managers wishing to maximize their training practices should give strong consideration to CBI. Furthermore, such supervisors and managers would also do well to carefully look at the content of the CBI solutions already in use or under consideration for use, making sure that these programs are truly interactive and not just electronic page turners.

Furthermore, the results of this article also suggest many ways in which the antecedents to behavior should be arranged in a CBI environment, which are important to consider for training developers when designing their own training solutions. In contrast to theories such as constructivism that advocate learner controlled instructional sequences (Alberto & Troutman, 2003; Carnine, 1992; Hirsch, 1996), the conclusions here support approaches that advocate scripted instructional sequences. Utilizing a high number of practice items appears to be beneficial. When deciding on the modality for the instructional narration, using auditory delivery is recommended. Integrating visuals and graphics into CBI appears to have beneficial outcomes. In regards to the type of behavior to be evoked, the results suggest that responding should be kept at the overt level, as opposed to covert responding. Furthermore, learner responding in the form of composing a response (fill-in-the-blank) is recommended over selecting a response formats (multiple choice). If incentives are used, improved performance will be produced if incentives are contingent upon specific performance during learning, not just simply completing the program.

Some of the studies examined warrant further discussion. For instance, Segal et al. (2003) appears to stand in contrast to the other studies in that a video presentation was found to be just as effective as interactive CBI. However, there were methodological concerns that limit the conclusions to be drawn from this study. Namely, the video showed feedback for all possible answers, both correct and incorrect solutions. The CBI program only showed feedback for solutions the learner selected. As such, the learners in the video condition were exposed to considerably more details and instruction. Batchelder and Rachal (2000) is another study with unusual results. In that study, no differences were found between lecture alone and lecture supplemented with CBI. However, it is important to note that there were no gains in learning from pre- to posttest in either condition. The participants in the study were prison inmates, and as noted by the authors, the participants appeared more interested in an excuse to be out of their cells rather than learning any of the material. Shute et al. (1996) is another unusual exception, demonstrating no differences between a lecture format and interactive CBI. This study contains a noteworthy confound: learners in the lecture condition were told that there would be a posttest and all learners completed the curriculum, whereas learners in the CBI condition were not informed that there would be a posttest and many of them did not complete the curriculum prior to the posttest. Perhaps if the methodological concerns above had been controlled for, there may have been even further evidence of interactive CBI's effectiveness.

Only two studies found an alternative instructional method to be superior to interactive CBI (noninteractive conditions in both Howard-Jones & Martin, 2002c1 and Kerwin, 2006). In the Howard-Jones & Martin study, the authors noted that the interactions were designed to cover only some of the relevant material. Thus, it is possible that the interactions reduced attention to other relevant material for which no interactions were created, whereas in the noninteractive condition all of the material was given equal attention, ultimately resulting in a depressive effect on the test scores of the interactive condition. When the authors conducted a follow-up experiment (Howard-Jones & Martin, 2002c2) in which all of the relevant material was involved in the interactions, interactive CBI was found to be superior to noninteractive CBI. The reasons for the atypical results found in Kerwin (2006) are less clear.

There are a number of limitations to this review article worth noting. The studies often varied greatly in terms of research design and experimental rigor, yet these differences are not reflected in the data set. Only a small number of studies involved training settings, potentially limiting the generalization of results. Another potential limitation is the number of studies that were excluded due to the exclusion criteria. Unfortunately, there are a relatively small number of studies that meet such criteria. Although the number could be easily increased by including studies that were simply demonstrations (i.e., made no comparisons between formats or conditions), this would not aid in discovering best practices. Similarly, this number could also be greatly increased by including perceived gains in learning (self-report measures only such as "I feel like I learned more with this program"), but this may not necessarily tell us about real gains in learning, which is of paramount importance to organizations. Another shortcoming of this study is that PsycINFO was the only database used to identify articles. There may have been other articles that would have met the inclusionary criteria, but are not included in PsycINFO and thus not included in this review. Future reviewers may wish to broaden the scope to databases besides PsycINFO. Another weakness of this review is that there was little attempt to control for differences in experimental rigor between studies, with all studies being given equal importance. Future reviews of this type would benefit from an attempt to classify the results according to relative experimental strength.

Despite the advantages of CBI cited throughout this article, it should be noted that CBI is not a cure-all solution free of disadvantages. For example, CBI often requires a greater up-front investment for the development of training materials (Kruse & Keil, 2000). Certain affective, motor, and interpersonal skills may not be well suited for CBI (Heinich, Molenda, & Russell, 1993). Computer programming also has not yet reached a point where the correctness of complex learner answers can be easily evaluated (Chase, 1985). Some have tried to address this concern by utilizing a hybrid of CBI and human evaluators, where the majority of instruction is handled by CBI, but humans are still in charge of evaluating learner responses (see CAPSI for an example: Pear & Crone-Todd, 1999; Pear & Martin, 2004). Individuals in a CBI learning environment may experience a reduction in both social and cultural interactions (Heinich et al., 1993; Kruse & Keil, 2000). Ultimately, computers are not a magic fix for training, but require careful attention to design and learner behavior, which is often lacking in current CBI programs (Engelmann, 1992; Skinner, 1984; Tudor & Bostow, 1991). Interactive CBI can only reach its true potential through careful research and thoughtful implementation.

On the basis of this review, there are several possible directions for OBM researchers to pursue when investigating best training practices. Only 13 of the comparisons involved training situations. Although education and training are highly similar activities and all of the articles were selected with relevance to workplace training in mind (i.e., only studies with normal adults were included), it would be beneficial to the field if more studies of this type were conducted in workplace situations.

Besides investigating the usage of interactive CBI in various training situations, more studies on how altering the various aspects of CBI can improve training outcomes are warranted. For example, none of the studies compared computer programs where pacing was completely controlled by the learner versus pacing controlled by the computer. In regards to interactions, adding further practice items appears to be beneficial. However, the upper limit to such additions is unknown. In fact, discussions over lean programming would suggest that the addition of too many practice items might actually be harmful (Markle, 1990; Rummler, 1965). Further, whether such practice in a CBI format should be timed or untimed has not been established. Another area in need of more research is whether CBI works best via learning from definitions or examples/nonexamples. Although one study found that postfeedback delays improved performance (Kelly & Crosbie, 1997), more research is needed to better establish and expand upon this area. For example, when do such delays become so short that they lose their effectiveness or so long as to produce detrimental learner frustration? CBI comparisons of different types of feedback, direct comparisons of mastery and nonmastery learning, and performance dependent versus performance independent incentives are also lacking.

Ultimately there is much to discover about the ways to improve organizational training and the best practices of interactive computer-based training. Fortunately, due to behavior analysis' emphasis on carefully examining the environmental variables that influence behavior, behavior analysts are well suited to the task of pursuing such research.

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APPENDIX Summary of Studies Involving Interactive Computer-Based Instruction

Authors	Goal	Usage	Pace	Mastery	Response	Feedback	Incentives	Independent variables	Summary of the results
Aberson et al. (2003)	Education	Primary	Student	No	Select	Contingent-Specific	None	CBI tutorial and lab workbook	Performance higher under CBI tutorial
Armel & Shrock (1996)	Education	Primary	Student	No	Compose	None	Performance Independent	Required note taking, optional note taking, and no note taking	Performance higher under required note taking
Atkinson (2002c1)	Education	Primary	Student	No	Compose	None	None	Audio agent prompts, text agent prompts, and no prompts; animated agent, static agent, and no agent	Performance higher under audio agent; no differences between animated and static agent, but both improved performance over no agent
Atkinson (2002c2)	Education	Primary	Student	No	Compose	None	None	Audio agent prompts, audio only prompts, and text only prompts	Performance higher under audio agent prompts
Atkinson et al. (2005)	Education	Primary	Student	No	Compose	None	None	Human voice prompts and machine voice prompts	Performance higher under human voice prompts
Batchelder & Rachal (2000)	Education	Supplemental	Student	No	Unknown	Contingent-Specific	None	CBI/lecture format and lecture only format	No differences between conditions

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APPENDIX (Continued)

Authors	Goal	Usage	Pace	Mastery	Response	Feedback	Incentives	Independent variables	Summary of the results
Bell & Kozlowski (2002)	Training	Primary	Machine	No	Select	Contingent-Specific	None	Adaptive guidance (machine controlled) and learner control	Performance higher under adaptive guidance
Blasko et al. (2004)	Education	Primary	Student	No	Compose	Unknown	None	CBI format and lecture format	Performance higher under CBI format
Bodemer et al. (2004c1)	Education	Primary	Student	No	Select	Unknown	Performance Independent	Integrated graphics / text and split graphics / text; Overt response request and covert response request	Performance higher under integrated graphics / text; no differences between overt and covert response requests
Bodemer et al. (2004c2)	Education	Primary	Student	No	Select	None	Performance Independent	Integrated graphics / text with overt response request, integrated graphics / text with covert response request, and split graphics text with covert response request; scripted sequences and self-discovery sequences	Performance higher under integrated graphics / text with overt response requests; performance higher under scripted sequences

Brothen & Wambach (2004)	Education	Supplemental	Student	No	Select	Contingent-Nonspecific	Performance Dependent	Timed and untimed quizzes	Performance higher under timed quizzes
Clariana (2003)	Education	Supplemental	Student	No	Various	Contingent-Nonspecific	Performance Independent	Compose and select response requests	Performance higher when learners must compose responses
Clariana (2004)	Education	Supplemental	Student	No	Various	Contingent-Nonspecific	None	Compose and select response requests	Performance higher when learners must compose responses
Connolly et al. (2007)	Education	Primary	Student	No	Unknown	Unknown	None	CBI format and lecture format	Performance higher under CBI format
Cook et al. (2007)	Education	Primary	Student	No	Mixed	Unknown	None	Interactive CBI and noninteractive CBI	No difference between conditions
Croninger et al. (1995)	Education	Supplemental	Student	No	Select	Contingent-Nonspecific	None	CBI / lecture format and lecture only format	Performance higher under CBI / lecture format
Crooks et al. (2007)	Education	Primary	Student	No	Compose	None	None	Composed summary notes and copied verbatim notes; small and large graphical organizers	No main effects between conditions; summary notes more effective when using large graphical organizers and verbatim notes more effective when using small graphical organizers

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APPENDIX (Continued)

Authors	Goal	Usage	Pace	Mastery	Response	Feedback	Incentives	Independent variables	Summary of the results
Darabi et al. (2007)	Education	Primary	Student	No	Unknown	Unknown	None	Interactive problem-solving, noninteractive process worked examples, and noninteractive product worked examples	Performance higher under interactive problem-solving
Davis et al. (2007)	Education	Primary	Student	No	Compose	Contingent-Nonspecific	None	Progressive prompting, traditional interactive, and noninteractive CBI	Performance higher under interactive conditions; no differences between interactive types
Dornisch & Sperling (2006)	Education	Primary	Student	No	Compose	None	Performance Independent	Suggested interactive CBI and noninteractive CBI	No differences between formats
Eckerman et al. (2002)	Training	Primary	Student	Yes	Select	Contingent-Nonspecific	Performance Independent	Interactive CBI, viewing interactive CBI, noninteractive CBI, and training manual	Performance higher under interactive CBI

Evans & Gibbons (2007)	Education	Primary	Student	No	Select	Contingent-Specific	None	Interactive CBI and noninteractive CBI	Performance higher under interactive CBI
Fisher et al. (1999)	Training	Primary	Student	No	Select	Contingent-Specific	None	CBI format and workshop format	No differences between conditions
Fitzgerald (1995)	Education	Primary	Student	No	Compose	Unknown	None	CBI format and lecture format	Performance higher under CBI format
Flora & Logan (1996)	Education	Supplemental	Student	No	Select	Contingent-Nonspecific	Performance Dependent	CBI / lecture format and lecture only format	Performance higher under CBI / lecture format
Fox & Ghezzi (2003)	Education	Primary	Student	Yes	Select	Contingent-Nonspecific	Performance Independent	Exemplar training and definitional learning; fluency and practice	Performance higher under exemplar training; no differences between fluency and practice
Fox & Sullivan (2007)	Education	Primary	Student	No	Select	Contingent-Specific	Performance Independent	Classification training, multiple relations training, both, and none	Performance higher with classification training
Gattie & Bisantz (2006)	Education	Primary	Student	No	Select	Contingent-Specific	Performance Independent	Task information, cognitive information, and functional validity information	Performance higher with task information

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APPENDIX (Continued)

Authors	Goal	Usage	Pace	Mastery	Response	Feedback	Incentives	Independent variables	Summary of the results
Gibbons et al. (2001)	Education	Primary	Student	No	Compose	Noncontingent	Performance Independent	Comparative (expert) feedback and objective (learner) feedback; single step feedback and linked step feedback	Performance higher under comparative feedback; no differences between single step and linked step feedback
González & Birch (2000)	Education	Primary	Student	No	Compose	Noncontingent	Performance Independent	Textbook, basic CBI, multimedia CBI, and no training	No differences between training methods
Green et al. (2007)	Education	Primary	Student	No	Compose	Various	None	Branching and linear format	Performance higher under branching format
Hahne et al. (2005)	Education	Supplemental	Student	No	Select	Unknown	None	CBI / lecture format and lecture only format	No differences between instructional formats
Henry (1995)	Education	Primary	Student	No	Unknown	Unknown	None	Low learner control and high learner control	No differences between conditions
Hopkins (2002)	Education	Primary	Student	No	Mixed	Unknown	None	Expository (detailed rules) and discovery (examples / nonexamples)	No differences between conditions
Howard-Jones & Martin (2002c1)	Education	Primary	Student	No	Select	Noncontingent	None	Interactive CBI and noninteractive CBI	Performance higher under noninteractive CBI

Howard-Jones & Martin (2002c2)	Education	Primary	Machine	No	Compose	Unknown	None	Interactive CBI and noninteractive CBI	Performance higher under interactive CBI
Jenny & Fai (2001)	Life Skills	Primary	Student	No	Select	Unknown	None	CBI format and lecture format	Performance higher under CBI format
Johari (2003)	Education	Primary	Student	No	Mixed	Contingent-Specific	Performance Independent	CBI with graphs and CBI without graphs	Performance higher under CBI with graphs
Kalyuga et al. (1999)	Training	Primary	Machine	No	Select	Unknown	None	Audio narration, textual narration, and audio / textual mixture narration	Performance higher under audio narration
Kalyuga et al. (2000)	Training	Primary	Student	No	Select	Contingent-Nonspecific	None	Diagrams with audio, diagrams with text, diagrams with audio / textual mixture, and diagrams only	No differences between conditions
Katayama & Crooks (2003)	Education	Primary	Student	No	Compose	None	None	Interactive CBI and noninteractive CBI	Performance higher under interactive CBI
Katayama et al. (2005)	Education	Primary	Student	No	Various	None	None	Compose and select response requests	Performance higher under compose response requests

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APPENDIX (Continued)

Authors	Goal	Usage	Pace	Mastery	Response	Feedback	Incentives	Independent variables	Summary of the results
Kelly & Crosbie (1997)	Education	Primary	Student	Yes	Compose	Noncontingent	Performance Independent	Postfeedback delays and no postfeedback delays	Performance higher under postfeedback delays
Kerwin (2006)	Education	Primary	Student	No	Mixed	Unknown	None	Fully interactive CBI, partially interactive CBI, and noninteractive CBI	Performance higher under noninteractive CBI
Kritch and Bostow (1998)	Education	Primary	Student	No	Compose	Contingent-Nonspecific	None	High interactivity, low interactivity, yoked (same time as high), and no interactivity	Performance higher under high interactivity
Lusk & Atkinson (2007)	Education	Primary	Student	No	Compose	Unknown	Performance Independent	Animated agent prompts, static agent prompts, and no prompts; displaying one step at a time and displaying all steps simultaneously	Performance higher under animated agent prompts; performance higher when displayed one step at a time
Luyben et al. (2003)	Education	Primary	Student	Yes	Mixed	Contingent-Nonspecific	None	CBI and textbook	Performance higher under CBI

Maki & Maki (2003)	Education	Primary	Student	Yes	Select	Unknown	None	CBI format and lecture format	Performance higher under CBI format
Maki et al. (2000)	Education	Primary	Student	Yes	Select	Contingent-Specific	Performance Dependent	CBI and lecture format	Performance higher under CBI format
Martin et al. (2007)	Education	Primary	Student	No	Select	Contingent-Nonspecific	None	Full CBI program (information + objectives + practice with feedback + examples + review), CBI program without objectives, CBI program without examples, CBI program without practice, CBI program without review, and CBI program with only information	Performance higher under interactive CBI (conditions including practice with feedback)
Miller & Malott (1997c1)	Education	Primary	Student	No	Compose	Contingent-Nonspecific	None	Overt response request and covert response request	Performance higher under overt response request

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APPENDIX (Continued)

Authors	Goal	Usage	Pace	Mastery	Response	Feedback	Incentives	Independent variables	Summary of the results
Miller & Malott (1997c2)	Education	Primary	Student	No	Compose	Contingent-Nonspecific	Performance Dependent	Overt response request and covert response request	Performance higher under overt response request
Montazemi & Wang (1995)	Education	Primary	Student	Yes	Select	Contingent-Nonspecific	None	Mastery learning with timed review after errors and no mastery learning	Performance higher under mastery learning with timed review
Moreno & Valdez (2005c1)	Education	Primary	Machine	No	Compose	Contingent-Nonspecific	None	Integrated graphics / text, graphics alone, text alone; interactive CBI and noninteractive CBI	Performance higher under integrated graphics / text; mixed results in regards to interactivity
Moreno & Valdez (2005c2)	Education	Primary	Student	No	Compose	Contingent-Nonspecific	None	Timed and untimed CBI	No differences between conditions
Moreno & Valdez (2005c3)	Education	Primary	Student	No	Compose	Contingent-Nonspecific	None	Reset of multiple steps after error and reset of single step after error	Performance higher under reset of multiple steps after error
Morris (2001)	Education	Primary	Student	No	Select	Contingent-Specific	None	CBI, textbook, and no training	No differences between training methods

Morrison et al. (1995)	Education	Primary	Student	No	Select	Various	Various	KCR, delayed KCR, AUC, no feedback, and no questions; contingent incentives and noncontingent incentives	Performance higher under KCR and delayed KCR (no difference between KCR types); performance higher under contingent incentives
Munson & Crosbie (1998)	Education	Primary	Student	No	Compose	Contingent-Nonspecific	Various	Contingent incentives and noncontingent incentives	Performance higher under contingent incentives
Munyofu et al. (2007)	Education	Primary	Student	Yes	Select	Noncontingent	None	Animation only, text / animation focused only on current topic, text / animation focused on relationships between topics	Performance higher when text / animation focused on relationships between topics
Orey et al. (1998)	Training	Primary	Student	Yes	Select	Contingent-Specific	None	CBI format and lecture format	Performance higher under CBI format
Parchman et al. (2000)	Training	Primary	Student	No	Select	Contingent-Nonspecific	None	Multimedia CBI, basic CBI, game-based CBI, and lecture format	Performance higher under multimedia CBI
Pelayo-Alvarez et al. (2000)	Education	Primary	Student	No	Select	Unknown	None	CBI and training manual	Performance higher under CBI

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Authors	Goal	Usage	Pace	Mastery	Response	Feedback	Incentives	Independent variables	Summary of the results
Prestera et al. (2005)	Education	Primary	Student	No	Mixed	Contingent-Nonspecific	None	Screen colors match during instruction / testing and screen colors mismatching during instruction / testing	No differences between conditions
Reisslein et al. (2006)	Education	Primary	Student	No	Compose	Noncontingent	None	Showing worked out examples followed by problems, showing problems followed by worked out examples, and fading of prompts	No differences between conditions
Rohlman et al. (2004c1)	Training	Primary	Student	Yes	Select	Contingent-Nonspecific	None	CBI, training manual with quiz / answers, training manual with quiz only, training manual with no quiz	Performance higher under CBI and training manual with quiz / answers, no differences between CBI and training manual with quiz / answers

Rohlman et al. (2004c2)	Training	Primary	Student	Yes	Select	Contingent-Nonspecific	None	Interactive CBI, partial interactive CBI, and noninteractive CBI	No differences between conditions
Rohlman et al. (2004c3)	Training	Primary	Student	Yes	Select	Contingent-Nonspecific	None	Open book format during interactions and closed book format during interactions	Performance was higher under open book format
Schnackenberg & Sullivan (2000)	Education	Primary	Student	No	Mixed	Contingent-Specific	None	More practice items and less practice items; learner decides if more practice needed and computer decides if more practice needed	Performance higher under more practice items; no differences if learner or computer decides if more practice needed
Segal et al. (2003)	Life Skills	Primary	Student	No	Select	Contingent-Specific	Performance Independent	CBI and video tape	No differences between conditions
Sholomskas & Carroll (2006)	Training	Supplemental	Student	No	Mixed	Unknown	None	CBI / manual format and manual only format	Performance higher under CBI / manual format
Shute & Gawlick (1995)	Training	Primary	Student	No	Compose	Unknown	Performance Independent	More practice items and less practice items	No differences between conditions
Shute et al. (1998)	Education	Primary	Student	No	Select	Contingent-Specific	Performance Independent	20, 14, 5–20 (learner decided), 11, and 5 practice items	Performance higher under more (20) practice items

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Authors	Goal	Usage	Pace	Mastery	Response	Feedback	Incentives	Independent variables	Summary of the results
Shute et al. (1996)	Education	Primary	Student	Yes	Mixed	Contingent-Specific	None	CBI format, lecture format, and no instruction	No differences between instructional formats
Truman & Truman (2006)	Education	Primary	Student	No	Select	Unknown	None	Text only prompts and voice-only prompts	Performance higher under voice-only prompts
Tudor (1995)	Education	Primary	Student	No	Compose	Contingent-Nonspecific	None	Overt response request and covert response request	Performance higher under overt response request
Van Rooij (2007)	Education	Primary	Student	No	Select	Contingent-Specific	None	Interactive CBI and noninteractive CBI	Performance higher under interactive CBI
Whittam et al. (2004)	Training	Supplemental	Student	No	Select	Contingent-Specific	None	High, medium, and low quiz density	No differences between conditions
Yadrick et al. (1997)	Education	Primary	Student	No	Compose	Contingent-Specific	None	Multiple possible correct solutions and exact duplication of instructions	Performance higher under multiple possible correct solutions