Impact of Guided Exploration and Enactive Exploration on Self-Regulatory Mechanisms and Information Acquisition Through Electronic Search

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Following instruction in basic skills for electronic search, participants who practiced in a guided exploration mode developed stronger self-efficacy and greater satisfaction than those who practiced in a self-guided exploratory mode. Intrinsic motivation was not affected by exploration mode. On 2 post-training tasks, guided exploration participants produced more effective search strategies, expended less effort, made fewer errors, rejected fewer lines of search, and achieved higher performance. Relative lack of support for self-regulatory factors as mediators of exploration mode impacts was attributed to the uninformative feedback from electronic search, which causes most people to remain at a novice level and to require external guidance for development of self-efficacy and skills. Self-guided learning will be more effective on structured tasks with more informative feedback and for individuals with greater expertise on dynamic tasks.

With the accelerated growth of computerized information sources, electronic search is rapidly becoming critical in the acquisition of information for decision making. Increasingly, information is being stored and presented in electronic rather than in print form. Some experts estimate that more than half of the world's information is available only by electronic access (e.g., Cook, 1995), thus underscoring the need to master electronic information technologies to ensure maximum access to needed information.

The capability to explore electronic information sources may be increasingly important in many domains of human functioning, but novices typically invest as little as 30 min on learning the basic competencies of electronic search (Borgman, 1989). This is particularly limiting because task-generated feedback from electronic search is not highly informative regarding the effectiveness of strategies. For the nonexpert, there is often no way of knowing how many relevant records there are on the database being searched or if the records retrieved are the most relevant. Unless a person is motivated to continually develop and test alternative strategies to see how they influence the records retrieved, the basic electronic search competencies that they develop during their initial exposure will not improve with experience. One aim in our study was to test the relative effects of introducing guided versus self-directed (enactive) modes of exploration immediately following the development of basic competencies for electronic inquiry.

The exploration and testing of strategies needed for the development of search competencies through experience is often undermined by the fact that many people feel overwhelmed and distrust their ability to conduct electronic search activities (Kuhlthau, 1991). Our second aim, therefore, was to test the impacts of the different modes of exploration on the self-regulatory processes of participants, and whether the emergent differences in the self-regulatory mechanisms produced subsequent differences in strategies and performance of electronic inquiries.

Electronic Search

Although electronic search tasks can vary in the degree of complexity and how quickly they converge to the desired information set, the structuring of interrogations and search strategies is very similar across the whole domain. Search strategies are built by using keywords and other terms and Boolean connectors (and, or, etc.), which determine the pathways that get explored and the information retrieved on each pathway. This language has remained fairly stable for the past 2 decades and is used in a wide range of electronic search tasks (library databases, Web pages, Internet searches, etc.). Except for minor variations in the protocols attached to different commercial products, the basic processes of conducting electronic searches, described in more detail below, generalize across all types of electronic inquiry tasks and different search engines.

The search for information is often a cyclical, exploratory process. People make inquiries, receive feedback, evaluate the outcomes of their inquiries, and alter their search activities accord-
only one or two steps. On more complex tasks, the process becomes more convoluted and demanding, with each inquiry providing important input for constructing further inquiries. Success in obtaining the needed information will be strongly influenced by the exploration process, including the scope of search activities, the quality of the sources used, and the sequencing of search (Wood, George-Falvy, & Debowski, in press). Effort can also be wasted in redundant, nonproductive inquiries. For many problems, an effective sequence is to search broadly to identify a range of options in the initial steps of the process and then to search the options in greater depth (Payne, Bettman, & Johnson, 1993).

Modes of Exploration

Instruction in the use of the technology, the basics of the search language, and the development of strategies for electronic search can be covered in 30 min, but practice in the construction of search strategies is needed to consolidate that knowledge. When left to their own devices, novices may follow many different modes of exploration during their practice sessions. However, we were interested in the potential impacts of interventions that shaped the exploration mode adopted during practice, and with this aim in mind, we focused on two modes of exploration that have been described and applied in different domains of functioning. One is enactive exploration, based on process models of human exploration (Greif & Keller, 1990; Condry, 1977) and error management (Frese & Altman, 1989), which have been shown to influence intrinsic motivation, learning, and performance. The second is guided exploration, based on the guided mastery model of training outlined in social cognitive theory, which has been shown to be highly effective in transmitting knowledge, competencies, and self-beliefs conducive to cognitive, motivational, and affective self-regulation (Bandura, 1986, 1997).

In enactive exploration, individuals are provided with unstructured opportunities to explore and discover effective strategies either from the outcomes of their trial and error actions or from external sources of advice, such as on-line help functions for electronic inquiry (Frese & Altman, 1989; Greif & Keller, 1990; Wood, Kakebeeke, Debowski, & Frese, 2000). Enactive exploration is guided by the emerging problems and interests of the individual and is not predetermined or imposed by a trainer or training program. Decisions about what to explore and when to seek guidance are made by individuals, giving them total control and responsibility for their own learning. Self-guided exploration is supplemented with the positive framing of the errors that are typically encountered in practice as opportunities for learning (Wood, Kakebeeke, et al., 2000). People are encouraged to expect mistakes and to learn from them rather than to fear them or view them as evidence of a lack of capability. This reduces the likelihood of novices attributing difficulties in practice to a lack of skill and undermining their perceived efficacy.

The self-guided nature of enactive exploration has been identified as producing greater intrinsic motivation in learning endeavors than approaches that provide high levels of external guidance and stress the avoidance of errors (Deci & Ryan, 1980; Dormann & Frese, 1994), but exploratory modes of learning have several potential limitations. Without guidance, the mistakes and errors that often accompany self-guided exploration on complex tasks may undermine the achievements needed to develop a robust self-efficacy for the task and create feelings of dissatisfaction with the lack of progress. Learners may also develop metaphors and analogies to describe their understanding of electronic inquiry processes, which limit the development of more effective strategies (Allwood & Kalen, 1993; Gay & Mazur, 1989). An example of a commonly used metaphor that is associated with superficial but wide-ranging electronic search is “surfing the net” (Wood, Aikins, & Tabernero, 2000).

For the nonexpert, the potential benefits of enactive exploration may be further limited by the low fidelity of feedback from electronic search tasks. Enactive exploration modes of learning have been shown to be effective for tasks that provide clear feedback on the adequacy of responses (Frese et al., 1991; Robert, 1987). On electronic search tasks, novice searchers are often unable to accurately judge their progress or the adequacy of their responses, and they will continue with suboptimal strategies or make strategic shifts for reasons that are unrelated to the adequacy of existing strategies.

Self-guided exploration without any encouragement to frame errors positively typifies the natural learning processes of most novice electronic searchers (Borgman, 1989) and may partially explain the poor electronic search strategies of nonexperts identified in other descriptions of the task (Brown, 1995; Collantes, 1995; Harter & Cheng, 1996; Wildemuth, de Bliek, Friedman, & File, 1995). The manipulation of enactive exploration, described later, was intended to be a stronger form of self-guided exploration than that which is typically used by novices, who may be more prone to dissatisfaction and to drops in efficacy as a result of problems encountered in practice.

In guided exploration, the sequencing of search activities and responses to problematic situations are predetermined according to a set of principles that have been found to strengthen the self-efficacy beliefs of trainees (Bandura, 1997) and are not left to the preferences and ad hoc responses of the novice. The principles are progressive achievement and cognitive modeling, which includes demonstrations of responses to problems encountered in practice and the verbalization of the thought processes that guide the choice of responses (Gist, 1989; Meichenbaum, 1977; Schunk, 1989). In guided exploration, practice sessions are used to explore the task in a systematic and preplanned manner. Tasks are completed in an assigned order that provides practice on tasks of increasing difficulty. The guided enactment of practice tasks ensure that the novice has a progressive sense of achievement, which strengthens perceived efficacy for the more demanding forms of the task and satisfaction with progress (Bandura, 1997). Guidance in the sequencing of practice tasks is supplemented with guidance in the choice of responses to problems, through cognitive modeling of responses from among those taught in the introductory training session. This further strengthens perceived self-efficacy for using and refining strategies (Latham & Saari, 1979).

Modeling of responses to problems also augments the less informative task feedback from electronic search by providing trainees with a signal regarding the adequacy of their response plus an immediate description of a standard with which they can compare their own action. The combination of an implicit feedback—standard comparison and demonstration of a response for removing the identified gap facilitates a motivated task focus, a condition under which feedback is most likely to enhance learn-
ing and performance (Kluger & DeNisi, 1996). The augmented feedback received under guided exploration can be contrasted with that received from enactive exploration, in which the only feedback is the list of records retrieved by the search statement, which the searcher may scan for their relevance to the search task. To compare their strategy with the standards covered in the instructional phase of their learning, self-guided explorers must either recall those standards or refer to the available instructional information. There is no direct feedback from the task or any external source regarding the adequacy of the search strategy used or the standards for judging the outcomes.

### Self-Regulatory Mechanisms

Acquiring information through electronic search requires more than the mechanical application of rules to a database. For a person with basic operational competencies, the effective use of search skills is a challenging process, which requires a robust belief in one's capability to master the task, positive affective reactions to progress achieved, and a sustained interest in the task (Bandura, 1997). The impacts of the progressive mastery and modeling components of guided exploration on posttraining performance have been found to be mediated through perceived self-efficacy and affective self-reactions (Bandura, 1997; Gist, 1989; Gist, Schoorer, & Rosen, 1989; Williams, 1990). Enactive exploration has been shown to lead to increased intrinsic motivation (Wood, Kakebeeke, et al., 2000).

Performance of complex activities that have extensive exploratory requirements is strongly influenced by beliefs of personal efficacy. Perceived efficacy affects problem-solving performance, both directly and by its impact on other self-regulatory determinants (Bandura, 1997). Such beliefs influence the choices people make, their goal aspirations, how much effort they mobilize in a given endeavor, how long they persevere in the face of difficulties, their vulnerability to stress and depression with taxing demands, and their resilience to adversity. With regard to cognitive functioning, people of high efficacy display strategic flexibility, are quicker to discard faulty strategies in search of better ones, are less inclined to prematurely discard good solutions, use good time management, and interpret deficient performance in informative rather than in self-debilitating ways (Bandura, 1997; Bouffard-Bouchard, Parent, & Larivee 1991; Wood & Bandura, 1989).

Affective reactions to the task will also influence the behavioral and cognitive functioning required for effective electronic search. If successful performance is obtainable solely by enhanced effort, then level of dissatisfaction raises performance accomplishments (Bandura & Cervone, 1983, 1986). As tasks become more complex and performance is more strongly determined by strategies, self-dissatisfaction may initially spur increased effort but undermine subsequent motivation and strategic thinking (Bandura & Jourden, 1991; Cervone, Jiwani, & Wood, 1991). Negative affect can interfere with the higher level cognitive processing required for generating options, interpreting feedback, and adapting strategies accordingly.

Intrinsic motivation can also affect search performance through several different pathways (Bandura, 1997; Deci & Ryan, 1980; Dorrman & Frese, 1994). Intrinsic motivation is typically associated with freedom from distracting negative self-evaluations and a strong task focus, both of which can benefit performance on complex cognitive tasks. Enjoyment of an intrinsically motivating task can also lead to persistence and a greater willingness to explore and experiment with alternative strategies. When tasks are experienced as boring or frustrating, individuals are more likely to become distracted, to spend less energy exploring options, and to look for opportunities to quit (Deci & Ryan, 1980; Dorrman & Frese, 1994).

Figure 1 presents a path diagram of the relationships between the variables mentioned in the preceding discussion. On the basis of the arguments presented, the following specific hypotheses were advanced for the impacts of the exploration mode used in practice, following instruction in the basic competencies of search.

**Hypothesis 1:** Guided exploration will produce stronger self-efficacy and greater satisfaction following practice than enactive exploration.

**Hypothesis 2:** Enactive exploration will produce greater intrinsic motivation following practice than guided exploration.

**Hypothesis 3:** Enactive exploration will produce greater wasted effort in the form of errors, repetition of search lines, and incomplete development of search statements in posttraining tasks than guided exploration.

**Hypothesis 4:** Guided exploration will lead to higher quality strategies and higher performance in posttraining tasks than in enactive exploration.

**Hypothesis 5:** The impacts of exploration mode on wasted effort, strategy, and performance in posttraining tasks will be mediated through the intrinsic motivation, self-efficacy, and satisfaction levels of participants.

### Method

The 2 × 2 experimental design included mode of exploration (guided vs. enactive) as a between-participants factor and two posttraining search tasks (Task 1 and Task 2) as a within-participants factor. Records of the searches conducted on the two posttraining tasks provided measures of effort, strategy quality, and performance. Self-regulatory measures were collected pre- and posttraining and after each of the posttraining search tasks. During training, all participants received the same instructional segment covering the basic competencies of electronic search. A practice segment that included the manipulations of exploration modes followed. All participants were novices in electronic search.

### Participants

The participants were 48 university students undertaking an introductory economics subject. Prior testing established that all participants had little or no experience in electronic search. The participants were randomly assigned to the experimental conditions.

![Figure 1](image-url). Schematic diagram of the hypothesized relationships between exploratory mode, self-regulatory reactions, effort, strategy quality, and performance on electronic search tasks.
no prior experience in the conduct of electronic searches (Internet, etc.), and no participant had ever conducted an electronic search of library records, which was the task used in this study. The sample included 25 male and 23 female students with a mean age of 19 years. They were randomly assigned to treatment conditions balanced for sex.

**Electronic Search Tasks**

One form of electronic search that is of growing importance to a wide range of decision making is the interrogation of bibliographic databases. The records stored in bibliographic databases include published journal articles, unpublished papers, books, technical reports, videos, and movies. Each record within a database is indexed under a range of keywords. Participants were assigned problems containing sets of concepts for which they had to find the relevant records from a bibliographic database.

To search the database, participants had to construct search statements that contained terms, known as keywords and connectors. The terms used to define the concepts in a search problem can be obtained from personal knowledge, the database keyword index, the thesaurus, or interim feedback from inquiries. The number of keywords for a concept will depend on the number of subconcepts and indicators encompassed by the concept. A search that incorporates keywords listed in the database index is more likely to retrieve relevant records, but personal judgment in the indexing process can provide an unpredictable element in the relevance of search outcomes. The thesaurus can be used to expand and redefine concepts, and it is therefore of greater value when the concept can be defined in a number of ways. However, it also requires more cognitive effort to identify keywords by using the thesaurus than the keyword index. More sophisticated searchers will review records in the interim feedback for relevant keywords and then use the thesaurus to link these to other keywords.

The keywords or terms included in a search statement are linked together with Boolean connectors, including the words **and** and **or**. The **and** connector narrows the scope of the search to those records that are indexed under all of the connected terms. The more keywords connected, the more focused the inquiry becomes and the fewer the records likely to be retrieved. The **or** connector broadens the focus of the search to retrieve all records that are indexed under any of the connected terms. This can produce a large number of records, depending on the diversity of the included concepts.

Each search statement retrieves a certain number of records from the database. These records can be inspected on the computer screen and assessed for their relevance. On the basis of these assessments, searchers can then modify their inquiry and interrogate the database further to increase the number of relevant records and reduce the number of irrelevant ones. The inquiry process can proceed through a number of iterations until the searcher retrieves an appropriate set of information.

**Modes of Exploration**

The training that included the manipulation of the exploration modes was conducted in two segments: an instructional segment followed by a practice segment. The format of a brief instruction segment followed by practice opportunities was similar to that used in other studies of computer software training (e.g., Martocchio & Dulebohn, 1994). All aspects of the instructional segment of the training were the same in both conditions and provided participants in both conditions with the same information. The manipulations of enactive exploration and guided exploration modes were introduced in the practice segment. The instruction and practice segments each took 30 min and were administered to individual participants by a female librarian who was highly experienced in CD-ROM searching and training.

In the common instructional segment, all participants were provided with an overview of the CD-ROM database, descriptions of the most effective search strategies for retrieving documents, and instruction in the use of the various computer operations and their functions. The search tools were described, and the instructor demonstrated how to use the Quick Reference Guide, the Thesaurus, the Keyword Index, and the On-Line Help and Guide services for the CD-ROM database. The phases of inquiry in an effective search strategy were described and demonstrated through an example search for information regarding the effects of **mass media on violent behavior**. The sequential strategy presented to participants was taken from the supporting documentation for the Silverplatter search service, which was the source for the CD-ROM databases searched by participants in this study. The basics of the strategy presented were the same as those presented in the search documentation for most commercially available databases.

Each of the prescribed eight steps in the strategy were described and then demonstrated by the instructor. The eight steps were as follows: Step 1: Select a concept; Step 2: Identify several correct terms to describe the concept, using self-selected keywords, the index, or the thesaurus; Step 3: Link these with **or**; Step 4: Repeat Steps 1 to 3 for additional concepts until all are defined; Step 5: Link groups of terms for each concept with **and** to find the common records; Step 6: Evaluate the suitability of the records obtained; Step 7: Rework any inappropriate concept terms by repeating Steps 2 and 3; and Step 8: Repeat Steps 5 and 6 and continue until most of the records retrieved are related to the assigned topic.

At each step, the instructor demonstrated alternative actions and then highlighted the relevant aspects of the outcomes for the participant. The participant was then asked to repeat the actions. For example, at Step 2, the instructor would say, "I can just think of some words to use as terms for the mass media concept, such as . . . " which she would write down. Then she would ask the participant to do the same for the violent behavior concept. Next, she would say, "I can also use the keyword index to find some terms that I might not have thought about," and she would then demonstrate the use of the keyword index by locating several terms and writing them down. The participant would do the same for the violent behavior concept. Finally, the instructor would say, "I can also use the thesaurus to identify related words that are not obvious from the keyword index," and she would locate two different synonyms in the thesaurus and write down the related terms. The participant would then do the same for the violent behavior concept. For Steps 3 to 5, the instructor entered some search statements into the computer and drew the participant's attention to the salient aspects of the output. The participant then repeated the process. All participants were given a one-page summary of the eight-step strategy process, which they were able to refer to at any stage during the practice segment and the performance tasks.

Following the instructional segment, participants completed a practice segment under either enactive or guided exploration instructions. Participants in both conditions explored the same five practice topics. They were (a) the effects of **alcohol use** on **academic performance**, (b) the effects of **child care** on **social skills**, (c) issues related to **migrants learning another language**, (d) the link between **physical activity** and **personality development**, and (e) the impact of **computer technologies** on the **design of buildings**.

**Enactive exploration** included instructions that covered self-guided exploration, the use of an on-line help facility that provided documentation of strategies and responses to problems, and the positive framing of errors (Frese et al., 1991; Wood, Kakebeeke, et al., 2000). Participants were told they could complete their inquiries on the five practice topics in any order or practice on topics of their own devising, as they would do if they were learning how to conduct searches by themselves. They were encouraged to explore and to practice, using the competencies they had learned in the instructional segment. The sequencing of tasks, the steps in the strategy process practiced, and the responses to problems were left to the discretion of the individual participant.

Enactive exploration participants had access to an on-line help facility with supporting printed information. The help facility was demonstrated so that participants knew how to access information, and they were reminded
of its availability when they encountered problems. They also had the summary sheet, which described the eight-step strategy that had been presented in the instructional segment. The on-line help facility and strategy summary sheet, which are commonly available to people who conduct electronic searches, meant that participants in the enactive exploration condition had available to them the same information that was provided to guided exploration participants through the modeling of responses. However, the decision to refer to them during practice was at the discretion of the individuals in the enactive exploration mode.

To encourage exploration during practice, we gave the enactive exploration participants instructions to frame errors and problems positively. These error management instructions were adopted from Frese et al. (1991) and were summarized in two signs that were placed on top of the computer in the participants’ line of sight. The first sign stated the following: “If you strike a problem, regard it as a learning opportunity; I have made an error: Great! There is a way to solve this problem. I can learn from this error.” The second sign stated the following: “Don’t forget to watch the screen; view the screen and see what is changing.” These principles were stated by the experimenter at the start of the practice session and whenever participants encountered problems.

Before commencing the practice segment, participants were asked if they understood that they could work through the tasks in whatever order suited them, and they all said yes. All participants also indicated that they knew how to use the on-line help facility. The participants were asked to read the error management signs, and the instructor reinforced the error management message during the practice session. If participants in the enactive exploration mode could not solve a problem after 3 min, then the instructor corrected the error and reminded them of the on-line help facility but did not explain the solution. Only 2 participants required this assistance, each on one occasion. In one case, the person continually omitted the symbol used to identify lines of search. In the second case, the person continually left no spaces between keywords. On all other occasions, participants in the enactive exploration condition corrected errors well within 3 min. The number of practice tasks completed varied according to the exploration interests of the individual.

Guided exploration included instructions on the order for completing the practice tasks, reminders of the steps to follow in developing a strategy for each task, and modeling of responses that followed problems or mistakes in the use of strategies during practice. All guided exploration participants completed the five practice topics in the same assigned order, progressing from the easiest to the more difficult searches, and they were instructed to work sequentially through the eight steps of the prescribed strategy for each topic. If the participant did not follow the prescribed strategy or made a mistake, then the instructor would model a response for that step, including a statement of the rationale that guided the selection. For example, if the participant simply started entering keywords on Step 2 for the first topic, then the instructor would say, “Drinking is one of the terms I have identified for alcohol use, but I know I will have more success if I find some other relevant keywords from the thesaurus.” She would then open the thesaurus and point to some relevant keywords. If participants skipped a step, then the instructor would draw their attention to the strategy summary sheet and remind them of the benefits of following the prescribed sequence. The modeled responses by the instructor only demonstrated points that had previously been covered in the common instruction segment, and they followed scripted procedures taken from the on-line help facility that was available to the enactive exploration participants during the practice segment.

In summary, the sequencing of tasks, the steps in the strategy process practiced, and the responses to problems were externally directed in the guided exploration mode but were left to the discretion of the individual searcher in the enactive exploration mode. Participants in the two exploration modes received the same information and level of instruction during the instructional segment, and no new information was introduced in the practice segment of the training program. The information on responses to problems encountered in practice was, however, presented differently in the two exploration modes. The experimenter modeled this in the guided exploration condition, whereas participants in the enactive exploration condition had to either refer to the on-line help facility (which was also available as a written document on their desktop computer) or rely on recall of information from the instruction segment.

Postinstruction Performance Assessment

Following the practice session, participants completed inquiries on two different tasks. One inquiry asked for information on the effects of television watching on teenagers in references published since 1988, and the other one asked about the impacts of technology on teacher satisfaction and performance. Half of the participants in each exploration condition completed the television effects task first and the technology effects task second. The other half of the participants completed the two searches in the reverse order.

Personal Variables

At the outset of the study, background information was collected on participants’ age, year of study, and previous computing, library, and electronic search experiences. Background measures also assessed the participants’ experience in searching library databases and manual indexes. The perceived effectiveness of the instructional programs and intrinsic motivation were assessed at the end of the practice segments of the training program. Perceived self-efficacy and self-satisfaction were assessed at four points: at the beginning of the study, at the end of the practice segment, and after each of the two searches in the postinstruction assessment phase.

Self-efficacy was measured with a 27-item scale, which covered the diverse activities in the four subfunctions of the electronic search process: problem definition, keyword identification, use of connectors and the thesaurus and point to some relevant keywords. If participants skipped a step, then the instructor would draw their attention to the strategy summary sheet and remind them of the benefits of following the prescribed sequence. The reliability estimates for each of the four assessments of self-efficacy were high (α > .95). Satisfaction was assessed with six items in which participants rated their level of satisfaction with their search skills and performance. The scale included items such as “At this point in time, how satisfied are you with your skill in conducting CD-ROM searches?” Participants rated their satisfaction on a 10-point scale ranging from 1 (not at all satisfied) to 10 (highly satisfied). The reliability estimates for each of the four assessments were at acceptable levels (α > .77).

Intrinsic motivation was assessed with seven items, including four items from the measure developed by Mossholder (1980) and three items from Daniel and Esser’s (1980) items. Participants assessed their desire to continue working on the task, their level of interest in the activity, their perceived degree of challenge, and their satisfaction with the task. The items were anchored with 1 (not at all) and 7 (to a large degree). Daniel and Esser’s (1980) items were 7-point semantic differential scales with the following anchors: monotonous—exciting, boring—interesting, and stimulating—dull. Principal-components factor analysis revealed that the seven items from the combined scales loaded on a single factor with high interitem reliability (α = .94).

Perceived training effectiveness was participants’ ratings of the modes instructions. Participants rated whether they found the process easy to
understand, whether too much information was provided, and whether they could easily recall the procedural strategy steps. They recorded their judgments on a 7-point scale, anchored by 1 (totally disagree) and 7 (totally agree). The reliability coefficient for the three-item scale was acceptable ($\alpha = .80$).

**Search Activity and Performance Attainment**

Printouts of the search records were used to assess effort, strategy quality, and performance levels.

*Total effort* in electronic search is reflected in the number of search statements developed and how extensively they are used. A search statement consists of keywords, other terms, and connectors; and it can be linked to other search statements by using additional connectors. The identification of terms and connectors requires significant cognitive effort. Thus, one indicator of effort is the number of terms and connectors included in search statements (Salterio, 1996). Time spent on the task is another indicator of effort. Participants had a maximum of 30 min to search for each of the problems in the testing phase, but they could spend less time if they wished. An additional effort indicator is the number of different lines of inquiry produced by the participant and integrated into the search. The computational lines of inquiry generated by the operating system and not developed directly by the participant were not included in this measure of effort. An aggregate index of total effort was created by summing the standardized scores for the three components of effort, which had acceptable levels of internal reliability for both the first and second tasks ($\alpha_1 = .83$, $\alpha_2 = .81$).

*Wasted effort* was measured in three ways: the number of repetitive or redundant lines of search generated, the lines of inquiry developed and rejected by the searcher in the process of developing the final search statement, and the number of errors. An aggregate measure of wasted effort was created from the standardized scores of these three components for the two tasks ($\alpha_1 = .70$, $\alpha_2 = .83$). Wasted effort is a component of total effort. Any increase in wasted effort due to rejected lines of search inputs must be associated with an increase in the number of lines and terms used to calculate total effort, as both measures are drawn from the same lines of search inputs. However, the reverse is not true. A searcher could input large numbers of search statements without rejecting any lines of search. The other components of the two effort measures are not directly related by source of measurement.

*Strategy quality* was a composite measure of the depth, breadth, sequencing, and sources used in the searches for the two tasks. Strategies were extracted from the printouts of search statements used to explore each of the assigned tasks. The expert librarian who conducted the training later scored each of the search strategies on the four properties, as described below. Hard copies of the 96 search records (two search tasks per subject) were given to the librarian 2 weeks after all the training was completed. No information on the searches identified the participant or the condition in which the search was completed. Randomization of the order also meant that any 2 consecutive searches were not necessarily from the same participant. To establish the reliability of the scores, a second librarian scored a 20% random sample of the search printouts. A common scoring checklist was used to ensure the same method of assessment throughout the scoring processes of both raters. This scoring sheet was tested in a prior pilot study, and it had been compiled from an analysis of 40 earlier searches. The interrater reliability across both tasks for the overall strategy score was $r = .95$.

*Depth of search* was calculated from the number of different keyword terms used to describe each concept that was linked with the *or* connector. The more keywords used for each concept in the search process, the greater the depth of search for that concept. The depth score for each search ranged from 0 to 12.

*Breath of search* was a measure of the number of concepts covered by terms included in search statements and correctly linked by using either the *and* connector or other concept refinement strategies such as field limiters, truncation, and the *not* connector. Points were allocated for each of these elements of breadth. The more concepts effectively linked in a search, the greater the breadth of the search. The scores ranged from 0 to 12 on each of the assigned topics.

*Search sequence* was operationalized as the degree to which the searcher combined the different steps into a coherent sequence, proceeding from exploration of single concepts in depth to a broader search of multiple concepts. This measure identified the degree to which the adopted search matched the procedural strategy outlined earlier, which has been demonstrated to be a highly effective search strategy (Michel, 1994; Quint, 1991). Participants had a description of the optimal sequence to refer to during practice. The scores for quality of search sequence on each search problem ranged from 0 to 12.

*Sources* of terms included in the search statement were the fourth component of strategy. Terms could be obtained from four different sources that varied in the difficulty of their use and the quality of terms. They included the initial search statement; the thesaurus; the keyword index; and other sources, such as the learners’ own knowledge and retrieved records. Thesaurus keywords are the most accurate in their detailed depiction of the topic, but they are also the potentially most difficult to use in search statements. The extent of thesaurus usage provided an operationalization of quality of sources.

The standardized scores for depth, breadth, sequence, and sources were combined to create an aggregate score for search strategy. The internal reliabilities for the strategy composites on the first and second tasks were acceptable ($\alpha_1 = .89$, $\alpha_2 = .71$).

*Performance* was the number of relevant records retrieved by the final search statement for each task. A record was categorized as relevant if it represented terms from the assigned topic and was linked with the *and* connector or other concept refinement strategies such as field limiters, truncation, and the *not* connector. Sources that varied in the difficulty of their use and the quality of terms. The librarian who scored strategy also scored performance. The search outputs were scored randomly and contained no information to identify the participant or the condition in which the search was conducted. A 20% random sample of search outputs was scored by the second librarian, yielding an interrater reliability across both test tasks of $r = .97$.

**Results**

Before we examined the pattern of relationships between study variables or tested the study hypotheses, we conducted analyses to test for potential differences in responses that were due to properties of the two performance tasks, the order in which the tasks were completed, or participant characteristics. All participants in both exploratory mode conditions completed the same two tasks, but the order was counterbalanced so that in each condition half of the participants completed the television effects task first and the other half completed the technology effects task first. With task and order of completion coded as dummy variables, there were no differences for task or order in which the two tasks were completed for any of the self-regulatory or outcome measures. The scores for the two performance tasks were standardized and combined for all analyses of the first (Task 1) and second (Task 2) tasks completed after the training.

Analyses of variance showed that the groups were comparable in age, level of prior search familiarity, and previous exposure to CD-ROM instruction. Although all participants were recruited from the same cohort and were randomly assigned to conditions, the guided exploration group was found to have more years of academic study than the enactive exploration group, $F(1, 46) = 9.10, p < .01, \eta^2 = .02$, and reported greater prior expe-
The most relevant demographic factor. The groups did not differ in experience with computers, $F(1, 46) = 4.79, p < .05, \eta^2 = .09$. These two personal variables were included as covariates in all reported analyses of covariance (ANCOVAs), unless specifically noted otherwise. All other variables were comparable for both groups, including CD-ROM experience, $F(1, 45) = 2.93, ns$, which was the most relevant demographic factor. The groups did not differ in self-efficacy or satisfaction at the outset, $F$s$(1, 46) < 1.0, ns$.

Table 1 presents the means, standard deviations, and correlation matrix for the study variables. The overall pattern of correlations was generally consistent with the relationships proposed in Figure 1, although the strength and significance of some relationships varied between Task 1 and Task 2. Some of the correlations in Table 1 were contrary to our expectations and require noting. Intrinsic motivation was not significantly related to exploration mode or to any of the effort, strategy, or performance measures. Total effort correlated highly with wasted effort on both tasks but not with strategy quality. Those who worked harder were more likely to waste their effort in errors, incomplete searches, and redundancies. Another interesting result was the lack of a relationship between Task 1 and Task 2 performance ($r = .02$). The issues raised by these results are addressed in the Discussion section.

**Effects of Exploration Mode on Self-Regulatory Factors**

Hypothesis 1 was supported. ANCOVAs showed that guided exploration was more effective in developing poststraining self-efficacy, $F(1, 45) = 19.15, p < .001, \eta^2 = .30$, and satisfaction, $F(1, 45) = 27.38, p < .001, \eta^2 = .37$, than enactive exploration (Figure 2). The self-efficacy of those who had practiced under guided exploration remained stronger than that of their enactive exploration counterparts after the first task, $F(1, 47) = 23.32, p < .001, \eta^2 = .34$, and second performance tasks, $F(1, 47) = 19.78, p < .001, \eta^2 = .30$. In a similar manner, the greater satisfaction of guided exploration participants was still evident after the first, $F(1, 47) = 33.75, p < .001, \eta^2 = .43$, and second tasks, $F(1, 47) = 23.16, p < .001, \eta^2 = .35$.

Hypothesis 2 was not supported. Intrinsic motivation did not differ significantly between the two modes of exploration. This unexpected result was somewhat contrary to impressions gained from direct observation of participants' behavior during the practice segment. During their practice searches, the enactive exploration participants often asked questions of themselves such as "How did I do that?" "What do I do now?" "What happens if I do this?" and "Let's see what else I can do." They moved freely between practice problems and appeared to be highly engaged in the process. Despite an apparent enjoyment of the process, enactive exploration participants evaluated the experience as less effective than guided exploration participants, $F(1, 46) = 23.56, p < .001$.

**Effects of Exploration Mode on Search Effort**

Hypothesis 3 was supported. ANCOVAs revealed that the enactive exploration participants wasted more effort across the two tasks, $F(1, 45) = 13.55, p < .001, \eta^2 = .23$ (Figure 3). They rejected more lines of inquiry, $F(1, 45) = 7.83, p < .01, \eta^2 = .15$, and they were more prone to errors, $F(1, 45) = 17.93, p < .001, \eta^2 = .28$. An analysis of variance without the two personal covariates showed that the enactive exploration participants also engaged in more redundancies than did their counterparts in guided exploration, $F(1, 45) = 4.55, p < .05, \eta^2 = .09$. However, this result was not significant in the ANCOVA with prior computer experience and years of academic study included as covariates, $F(1, 43) = 3.38, ns, \eta^2 = .07$.

**Effects of Exploration Mode on Strategy Quality and Performance**

Hypothesis 4 was supported for both strategy quality and performance. Repeated measures ANCOVAs showed that guided exploration participants demonstrated better quality search strategies, $F(1, 44) = 46.45, p < .001, \eta^2 = .51$, and retrieved more relevant records, $F(1, 44) = 6.53, p < .05, \eta^2 = .13$, across the two tasks than did the enactive exploration participants (Figure 4). The interaction terms for exploration mode by tasks were not significant for either strategy quality or performance.

More detailed analyses of the strategy components revealed that the guided exploration participants conducted a broader search on the first task, $F(1, 46) = 11.32, p < .001, \eta^2 = .20$, but, with experience, the enactive exploration group matched them in their search breadth on the second task, $F(1, 46) = 0.02, ns$. Guided exploration participants conducted searches of greater depth, $F(1, 46) = 23.96, p < .001, \eta^2 = .42$, and better sequencing, $F(1, 46) = 44.34, p < .001, \eta^2 = .49$, across both tasks. They also used more informational sources, relying more heavily on the thesaurus for their keyword selection, whereas their enactive exploration counterparts made limited use of this important source of keywords, $F(1, 46) = 54.28, p < .001, \eta^2 = .54$.

The results of the quantitative analyses for the components of wasted effort and strategy quality were supported by qualitative assessments of the search records. The librarian who scored the participants’ search strategies was instructed to review the search records a second time and to identify an example of the most common search behaviors from each search record. This review resulted in two examples for each participant. A review of these examples revealed that the enactive exploration participants often used the same terms repetitively, experimenting with different links and combinations, but not adding new terms that increased the depth of search for concepts. The other common enactive exploration strategy was to use different terms, only to discard them in favor of new terms, rather than to develop a coherent line of inquiry by adding the terms together in a single search statement. By this approach, they used many terms, but there was little strategy refinement or integration despite high effort. Guided exploration participants drew terms from the thesaurus and the index and, as shown in the results of the quantitative analyses, more effectively integrated these terms in their search statements than their enactive exploration counterparts.

**Mediating Role of Self-Regulatory Factors**

Hypothesis 5 received very limited support. The predicted mediation roles of self-efficacy, satisfaction, and intrinsic motivation for differences in wasted effort, strategy quality, and performance

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1 With rejected lines of work excluded from the wasted error measure, the correlations between total effort and wasted effort for Tasks 1 and 2, respectively, were $r_1 = .48, p < .01$, and $r_2 = .59, p < .01$. 

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**Table 1**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Task 1</th>
<th>Task 2</th>
<th>Task 1-Task 2</th>
<th>Correlation</th>
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<td>Wasted effort</td>
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<tr>
<td>Redundancies</td>
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</tbody>
</table>

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**Figure 1**

Graph showing the relationship between exploration mode and self-efficacy. Guided exploration participants had higher self-efficacy scores than enactive exploration participants.

**Figure 2**

Graph showing the relationship between exploration mode and satisfaction. Guided exploration participants reported higher satisfaction scores than enactive exploration participants.

**Figure 3**

Graph showing the relationship between exploration mode and total effort. Guided exploration participants expended more effort than enactive exploration participants.

**Figure 4**

Graph showing the relationship between exploration mode and strategy quality. Guided exploration participants displayed higher strategy quality scores than enactive exploration participants.
by participants in the two exploration modes were tested separately, using the three-step hierarchical regression procedure recommended by Baron and Kenny (1986). The results of these analyses, which are shown in Table 2, revealed no significant mediation effects on Task 1 and partial support for the mediation of performance differences on Task 2. The significant effect for strategy quality on Task 2 performance was a significant negative predictor of wasted effort ($\beta = -0.52$, $p < .05$) and a positive predictor ($\beta = 0.54$, $p < .05$), on both Task 1 and Task 2.

### Table 1

**Alpha Coefficients, Means, Standard Deviations, and Correlation Matrix for First and Second Posttraining Performance Tasks**

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<thead>
<tr>
<th>Variable</th>
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<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
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<td>—</td>
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<td>—</td>
<td>—</td>
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<td>4. Prior computer experience</td>
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<td>-0.03</td>
<td>-0.25</td>
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<td>.49**</td>
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</table>

**Total**

| $M$s | 0.50 | 19.40 | 2.04 | 8.57 | 5.64 | 3.16 | 5.96 | 6.18 |
| $SD$s | 1.22 | 0.54 | 2.03 | 1.21 | 1.46 | 2.02 | 2.10 | —    |

**Enactive exploration**

| $M$s | 0.00 | 19.21 | 1.83 | 7.96 | 5.06 | 3.12 | 4.86 | 4.97 |
| $SD$s | 1.06 | 0.56 | 1.68 | 1.26 | 1.44 | 1.75 | 1.68 | —    |

**Guided exploration**

| $M$s | 1.00 | 19.58 | 2.25 | 9.22 | 6.21 | 3.19 | 7.05 | 7.39 |
| $SD$s | 1.35 | 0.44 | 2.19 | 0.83 | 1.51 | 1.67 | 1.79 | —    |

**Guided vs. enactive**

| 0.37 | 0.95** | 1.26* | 1.15** | 0.07 | 2.19** | 2.42** |

*Note. Alpha coefficients are shown in parentheses on the diagonal. Exploration mode was dummy coded so that enactive exploration = 0 and guided exploration = 1. For guided vs. enactive, $F$s are from $1 \times 2$ analysis of variance for each study variable.*

$p < .06$.  $*p < .05$.  **$p < .01$.

### Discussion

As we hypothesized, practice under guided exploration produced higher levels of perceived self-efficacy, satisfaction, strategy quality, and performance and lower levels of wasted effort on electronic search tasks than self-guided, enactive exploration. Following instruction in the basic competencies, participants who had the benefit of guided exploration during practice worked smarter and more efficiently and exhibited less wasteful effort on later performance tasks. They spent less time on the tasks, developed better strategies, and reduced the amount of effort they needed to acquire the required information for assigned topics. These differences are especially noteworthy because participants in the enactive exploration condition were instructed in the effective strategy steps at the outset and had a description of these steps to refer to throughout the performance of the search tasks. This is a considerable aid if the person chooses to use it. The enhanced levels of self-efficacy and satisfaction produced by guided exploration in practice remained when participants conducted their searches for the performance tasks without any guidance.

An important feature of the electronic search task used in this study is that the natural task feedback provides little direct guid-
judgment their relevance for the problem being explored, the novices necessarily be translated into superior performance on tasks where or performance. Intrinsically motivated interest in a task will not motivation did not contribute to the prediction of strategy quality guided exploration by novices is less effective when feedback does improve performance (Dormann & Frese, 1994). However, self-guided exploration quickly leads to discoveries that can be used to greater intrinsic motivation for electronic inquiry. Encouraging reactions and task performance, as discussed below.

Contrary to our prediction, enactive exploration did not produce greater intrinsic motivation for electronic inquiry. Encouraging people to explore and to make errors can lead to heightened interest, persistence, and better performance on tasks where self-guided exploration quickly leads to discoveries that can be used to improve performance (Dormann & Frese, 1994). However, self-guided exploration by novices is less effective when feedback does not facilitate learning or positive motivation. Moreover, intrinsic motivation did not contribute to the prediction of strategy quality or performance. Intrinsically motivated interest in a task will not necessarily be translated into superior performance on tasks where working harder and longer is no guarantee of success (Bandura & Jourden, 1991; Wood, Kakebeeke, et al., 2000).

The very limited support for the hypothesized mediating functions of the self-regulatory reactions may also be due to the nature of task feedback from electronic search. When standards are unclear and feedback does not provide a clear indication of progress, self-regulatory reactions are less reliably related to future performance (Bandura, 1997; Cervone et al., 1991). Even if novices set goals based on the records retrieved, they may be using totally different standards from those used by experts to categorize records as relevant. In the absence of interpretable and reliable evidence regarding their progress on the task, participants’ efficacy judgments and their feelings of satisfaction were based on self-regulatory reactions are less reliably related to future perfor-

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</table>

6.70 | 3.27 | 6.14 | 6.54 | 7.01 | 4.89 | 53.92 | 24.60 | 3.47 | 2.63 | 50.47 | 25.17 | 3.65 | 3.23 |

2.10 | 1.18 | 1.71 | 1.77 | 1.77 | 0.97 | 22.53 | 26.80 | 2.03 | 2.61 | 25.89 | 37.98 | 1.57 | 7.01 |

5.56 | 3.12 | 5.10 | 5.38 | 5.95 | 4.72 | 59.71 | 32.96 | 1.97 | 1.92 | 58.39 | 42.39 | 2.71 | 1.04 |

2.01 | 0.97 | 1.48 | 1.47 | 1.74 | 0.81 | 24.25 | 24.22 | 0.81 | 2.14 | 32.61 | 48.26 | 1.10 | 1.55 |

7.83 | 3.44 | 7.17 | 7.68 | 8.02 | 5.07 | 48.12 | 16.25 | 5.00 | 3.33 | 42.88 | 8.67 | 4.59 | 5.42 |

1.49 | 1.38 | 1.25 | 1.23 | 1.09 | 1.10 | 19.48 | 27.13 | 1.76 | 2.87 | 14.17 | 8.76 | 1.76 | 9.38 |

2.27** | .32 | 2.07** | 2.50** | 2.07** | .35 | 11.59 | 16.71** | 3.03** | 1.41† | 15.51* | 33.72* | 1.88** | 4.38* |
Figure 2. Self-efficacy and satisfaction for guided exploration and enactive exploration groups at pretraining, posttraining, Posttask 1 and Posttask 2 assessment phases.

Interpreting feedback and deriving the connection between their search strategies and records retrieved, self-regulatory reactions should become more closely aligned to strategy quality and performance.

The results of the mediation analyses did show that the search patterns used by the participants during practice were carried over to their searches for the two performance tasks, independently of any motivational effects due to self-regulatory reactions to the search task. The low fidelity of task feedback from electronic search will often mean that inexperienced searchers will persist with the behaviors that they develop during training and practice. For novices who practice under self-guided exploration, this is more likely to include suboptimal strategies and inefficient behaviors.

The results of this study do not rule out the possibility that self-guided exploration will produce stronger motivation, better task understanding, and more effective strategies under different

Figure 3. Effects of guided exploration and enactive exploration on level of wasted effort as represented by lines of redundant search statements, lines of incomplete search statements, and number of errors committed for Posttraining Tasks 1 and 2.
circumstances. Enactive exploration may be better suited to tasks that include more informative feedback and to other forms of electronic inquiry, such as “surfing the net” to identify a particular Web site, which requires minimal competency in search procedures and allows superficial processing of interim feedback (Wood, Atkins, & Tabernero, 2000). For complex, ill-structured tasks that provide low-fidelity feedback, the evidence suggests that guided mastery training plus extended guided exploration during practice is needed to build initial competencies before the benefits of self-guided exploration will be realized. For example, Simon and Werner (1996) found that staff who learned how to use a new software program under a self-guided exploratory mode had still

![Table 2](image)

**Figure 4.** Effects of guided exploration and enactive exploration on strategy quality ratings and numbers of relevant records retrieved for Posttraining Tasks 1 and 2.

<table>
<thead>
<tr>
<th>Analysis step</th>
<th>Dependent variable</th>
<th>Independent variable</th>
<th>β</th>
<th>Adjusted $R^2$</th>
<th>β</th>
<th>Adjusted $R^2$</th>
</tr>
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<td>1</td>
<td>Self-efficacy</td>
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<td>.55**</td>
<td>.58**</td>
<td>.61**</td>
<td>.65**</td>
</tr>
<tr>
<td></td>
<td>Self-satisfaction</td>
<td>Exploration mode</td>
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<td>.19</td>
<td>.18</td>
<td>.19</td>
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<td>-.52**</td>
<td>.13**</td>
<td>.25**</td>
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<td>Wasted effort</td>
<td>Exploration mode</td>
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<td>-.53**</td>
<td>.13</td>
<td>.22**</td>
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<tr>
<td></td>
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<td>Self-efficacy</td>
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<td>.21</td>
<td>.34</td>
<td>.21</td>
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<tr>
<td>3</td>
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<td>Exploration mode</td>
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<td>-.16</td>
<td>-.10</td>
<td>-.16</td>
</tr>
<tr>
<td>2</td>
<td>Strategy quality</td>
<td>Exploration mode</td>
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<td>.60**</td>
<td>.54**</td>
<td>.35**</td>
</tr>
<tr>
<td>3</td>
<td>Strategy quality</td>
<td>Exploration mode</td>
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<td>.38**</td>
<td>.56**</td>
<td>.38**</td>
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<tr>
<td></td>
<td>Performance</td>
<td>Self-efficacy</td>
<td>.00</td>
<td>.14</td>
<td>.00</td>
<td>.14</td>
</tr>
<tr>
<td></td>
<td>Performance</td>
<td>Satisfaction</td>
<td>-.36</td>
<td>-.21</td>
<td>-.36</td>
<td>-.21</td>
</tr>
<tr>
<td>2</td>
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<td>Exploration mode</td>
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<td>.31*</td>
<td>.07†</td>
<td>.09*</td>
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<td>Self-efficacy</td>
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<td>.04</td>
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<td>.10</td>
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</tbody>
</table>

**Note.** Intrinsic motivation was not related to exploration mode or outcomes, either singly or in combination with the other self-regulatory variables. Therefore, it was not included in the subsequent steps of the mediation analysis.

† $p < .06$. * $p < .05$. ** $p < .01$. 

![Figure 4](image)
not matched the comprehension or skill levels of those taught by modeling after 1 month of on-the-job experience with the program.

Electronic inquiry is a major element in present-day life, and it is likely to play an even bigger role in the acquisition of information with further advances in electronic technologies. Most people will not receive extended training in electronic search, and experience may prove a poor teacher because of the lack of direction provided by task feedback. Support for self-improvement by people with basic electronic search skills is an important issue that requires further research. One area for future research is the impact of feedback interventions on the self-regulatory mechanisms and skill development of novice electronic searchers. Although the benefits of some feedback interventions have been found to be problematic (Kluger & DeNisi, 1996), those that enhance perceived efficacy and provide a functional task focus will lead to improved understanding and performance on complex tasks (Bandura, 1997; Martocchio & Webster, 1992). For example, Martocchio and Dulebohn (1994) found that augmentation of task feedback with information on factors under the control of the trainee led to greater understanding and better performance of a complex computer software program than supplemental feedback on factors outside the trainees’ control. Interventions to augment task feedback from electronic search could include similar types of diagnostics as well as feedback on compliance with strategy steps or redundancies and other forms of wasted error.

References


Received March 20, 2000
Revision received January 20, 2001
Accepted January 21, 2001