

The Multilevel and Multifaceted Character of Computer Self-Efficacy: Toward Clarification of the Construct and an Integrative Framework for Research

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Despite the recent empirical interest and advances in research with regard to the construct of computer self-efficacy (CSE), the results obtained to date have, in some cases, been either equivocal or contradictory. We suggest that such results may be attributable to a general lack of attention to the dynamic, multileveled, and multifaceted nature of the computer self-efficacy construct. We offer examples from the extant CSE literature suggesting weaknesses in existing measures of the construct as well as issues associated with manipulations and the need for control of antecedent and consequent factors directly associated with CSE. The objectives of this paper are: (1) to provide a thorough review of the extant literature related to CSE; (2) to present an integrated model of empirical findings, constructed from a wide variety of disciplines, that comprehensively defines the multifaceted nature of task-specific CSE in terms of its antecedent, consequent, and moderating factors; (3) to present a conceptual model of CSE at the general versus task-specific level; and (4) to use the two models of CSE to proffer guidelines for both measurement and manipulation of the construct. Through our review of the CSE literature, we offer several thoughts regarding the nature of the empirical results obtained to date. The combined objectives serve as a basis for establishing a foundation upon which future research investigating the CSE construct can be based.
(Computer Self-Efficacy; Social Learning Theory; Training Performance)

I. Introduction

There exists a widely held desire to achieve greater understanding of the various mechanisms employed by individuals in the development of their computer-related skills and their decision to use computers (Davis 1989, Davis et al. 1989, Doll and Torkzadeh

1988, Vessey and Galleta 1991, DeSanctis 1983, Taylor and Todd 1995). One example of this impetus is the research concentration on the construct of computer self-efficacy (CSE) defined as *an individual judgment of one's capability to use a computer* (Compeau and Higgins 1995a, p. 192). Though still in the early stages of investigation, it has been suggested that CSE plays a

significant role in an individual's decision to use computers, as well as in the ease with which many of the skills associated with effective computer use are acquired. While a number of IS studies have investigated the CSE construct in relation to both skill development and computer use, the totality of this research has yet to approach the depth of investigation into self-efficacy present in other knowledge domains.

Improving our understanding of the nature of the CSE construct from both an antecedent and consequent perspective should have positive implications for applied activities in computer training, education, implementation, and technology acceptance. We believe that success in finding relevant applicable training methods associated with the enhancement of CSE requires a more detailed and isolated explication of the construct than has been realized to date. Further, we consider the value of understanding self-efficacy as it relates to computer use to be significant to both the research and the applied communities. The research community can benefit from this understanding through improved measurement of the psychometric properties of the construct. Such improvements will allow for more accurate assessment of manipulations intended to produce a desired change in CSE or determination of the strength of various relationships between CSE and other use or performance-related factors. The applied community can realize significant benefits through improved and better targeted training mechanisms and, ultimately, through improved levels of performance in individual employees or group members.

The objectives of this paper are: (1) to present a conceptual model of CSE at both the general and task-specific level; (2) to present an integrated model of empirical findings derived from SE research, conducted in a wide variety of disciplines, that comprehensively defines the multifaceted nature of task-specific CSE in terms of its antecedent, consequent, and moderating factors; (3) to provide an exhaustive review of the extant literature related to CSE using the two comprehensive models as lenses to assist in explaining the empirical results in the CSE literature obtained to date; and (4) to use the two models of CSE to proffer guide-

lines for both measurement and manipulation of the construct.

The next section will provide a brief overview of Bandura's Social Learning Theory and the general concept of self-efficacy. Section III will focus attention on the concept of CSE by presenting comprehensive models of CSE at two levels containing both conceptual and empirically tested or derived antecedent and consequent elements and their relationships to CSE. Following this, Section IV offers a comprehensive review of the extant research literature focusing on the CSE construct integrated with a detailed discussion of each component of the model. Section V is devoted to a discussion of guidelines for research into CSE that emphasize issues related to measurement, manipulation, and/or control of each of the model's elements. Section VI concludes the paper with a discussion of the implications associated with application of the foundational empirical findings related to CSE on future research efforts.

II. Social Learning Theory and Self-Efficacy

Derived from the broader construct of self-efficacy, CSE's roots are found in the widely accepted and empirically rich model of individual behavior: Social Learning Theory (SLT) (Bandura 1977a, 1977b, 1978a, 1982, 1986).¹ SLT explains human behavior from the perspective of a continuous reciprocity among behavioral, cognitive, and environmental determinants. A key element in social learning theory is the concept of *self-efficacy* (SE), which refers to an individual's belief in his or her capability to perform a specific task. Estimations of SE are formed through a gradual and dynamic weighing, integration, and evaluation of complex cognitive, linguistic, social, and/or enactive experiences.

Over the past two decades, literally dozens of academic works have emerged, both conceptual and empirical, that focus on the concept of self-efficacy (both

¹Numerous examples detailing the foundational aspects of Bandura's (1977) Social Learning Theory exist (cf. Bandura 1977a, 1977b, 1982, 1986; Gist and Mitchell 1992). As such, only a limited amount of discussion will be devoted to the topic here.

Gist 1987 and Gist and Mitchell 1992 provide thorough reviews of the literature on self-efficacy). Along with each of these examples comes a definition of the construct that builds upon the initial work of Bandura (1977a, 1977b) in his seminal treatise on SE. Following Bandura's discourse, research made many attempts to capture and characterize more of the richness and multifaceted nature of the construct than had been attained previously. Regardless of the wording of the various definitions or the nature of the studies, however, two salient characteristics remain clear: SE is a strong predictor of subsequent task-specific performance, and all definitions of the construct ultimately refer to *what a person perceives their capabilities to be with regard to a specific task*.

Self-efficacy is a dynamic construct that reflects more than just an ability assessment, however. An individual's judgment of SE reflects an orchestration or mobilization component that includes both motivational and integrative aspects (Gist and Mitchell 1992, Wood and Bandura 1989b). In other words, SE reflects not only an individual's perception of his or her ability to perform a particular task based on past performance or experience but also forms a critical influence on future intentions. The principal point among the myriad definitions, interpretations, and explanations is that the estimation of self-efficacy is a composite of numerous factors, each of which serve to have a direct effect on the final individual judgment and on the relationship of that judgment to the actual performance.

SLT suggests that SE can vary across activities and situational circumstances and, as such, is not a global disposition which can be easily measured by an omnibus test (Bandura 1986). Further, it has been found that the predictive capability of an SE estimate is strongest and most accurate when determined by specific domain-linked measures rather than with general measures (Bandura 1989). Often, attempts are made to globally assess measures of SE at a single point in the judgment process as though they represented a static, unidimensional construct Bandura (1977b) suggests that such global, unidimensional measures reflect a mixture of, among other things, hope, wishful thinking, and faith in the therapist or manipulator. As such, global measures of SE generally bear little relation to the actual magnitude of behavioral change and become

problematic in their interpretation and conclusiveness. In short, the most reliable SE research findings are task-specific (Mone 1994).

Although Bandura's original application of the concept was developed in the context of treating severe phobics, recent research has found significant support for extension of the theory beyond its original therapeutic focus (Jorde-Bloom 1988; Eden and Aviram 1993; Schunk 1983, 1984, 1991).² The next section of this paper will focus on the construct of interest, *computer self-efficacy*. Two models are presented, each containing antecedent and consequent factors that have been empirically related to self-efficacy within a diverse spectrum of task domains.

III. Computer Self-Efficacy (CSE)

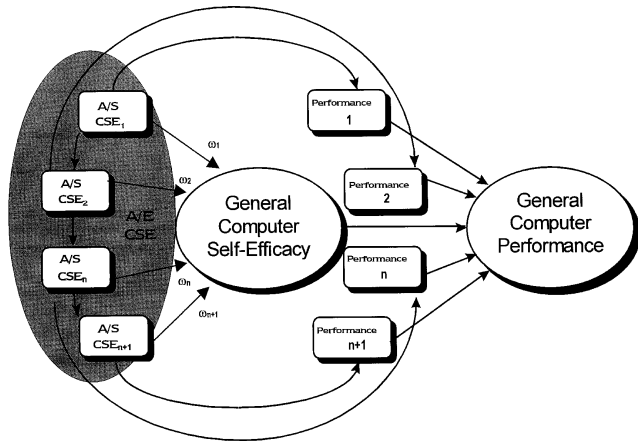
Of late, an increased focus on the various behavioral factors affecting computer use or performance has included the identification and measurement of CSE (Hill et al. 1987, Murphy et al. 1989, Compeau and Higgins 1995a). While the early research efforts in CSE have been both fruitful and informative, the IS community continues to focus its efforts on improving measurement of the construct and refining the methodological issues surrounding its manipulation.

The first step in more fully defining CSE is to focus attention on the multiple levels with which CSE can operate. As shown in Figure 1, CSE can be operationalized at both the *general* computing behavior level and at the *specific* computer application level. Within the task-specific levels we find CSE at both an *application environment* ([A/E] i.e., Windows 95 or NT 4.0 desktop environment) and *application-specific* ([A/S] i.e., word processor, spreadsheet, database, etc.) focus. **Task-specific computer self-efficacy** (CSE) refers to *an individual's perception of efficacy in performing specific computer-related tasks within the domain of general computing*.

This definition is more closely aligned with the original conceptualization of self-efficacy by Bandura. As discussed later in the paper, the differentiation of CSE at the application environment level and the

²Gist and Mitchell (1992) provide an excellent compilation of studies dealing with various subdomains of empirically based organizational research into self-efficacy.

Figure 1 Theoretical Model of General and Application-Specific Computer Self-Efficacy



application-specific level allows for the measurement of individual ability assessments that exclude the assessment of cross-domain skills necessary in the performance of a task requiring the use of a computer (i.e., preparation of a financial forecast using a spreadsheet). In other words, by focusing attention on the application independent of the task being performed with it, we can assess an individual's perception of ability to use the tool without constraining or bounding that assessment with a task situation requiring cross-domain knowledge. Conversely, *general computer self-efficacy* (GCSE) refers to *an individual's judgment of efficacy across multiple computer application domains*. GCSE is more a product of a lifetime of related experiences and tends to more closely conform to the definition of computer self-efficacy that is often offered and tested in the IS literature (i.e., Carlson and Grabowski 1992, Martocchio 1994). It can be thought of as a collection of all CSEs accumulated over time.

Each task-specific percept, either A/E or A/S, is associated with a specific task performance (n) and is, thus, a cognition about that specific performance. Each instance of CSE carries with it a weight (ω), which is unique to the individual and is derived from the combined antecedent and consequent factors associated with the formation of a task-specific self-efficacy perception. In the near term, the formation of a CSE estimation and its associated enactive experience can contribute to the formation of the next subsequent CSE

estimation. From a more distal perspective, however, each of the CSE percepts contribute to the formation of a perception of GCSE (Bandura 1997). We argue that GCSE and CSE are distinct theoretical constructs and, as such, cannot be treated interchangeably from either a measurement or manipulation perspective. In particular, we believe that given the definition of GCSE as a collection of CSE perceptions and enactive experiences, GCSE does not intuitively appear to be amenable to a measurably immediate change under any set of short-lived conditions. Correspondingly, its long-term usefulness may be as a predictor of future levels of general performance within the diverse domain of computer-related tasks.

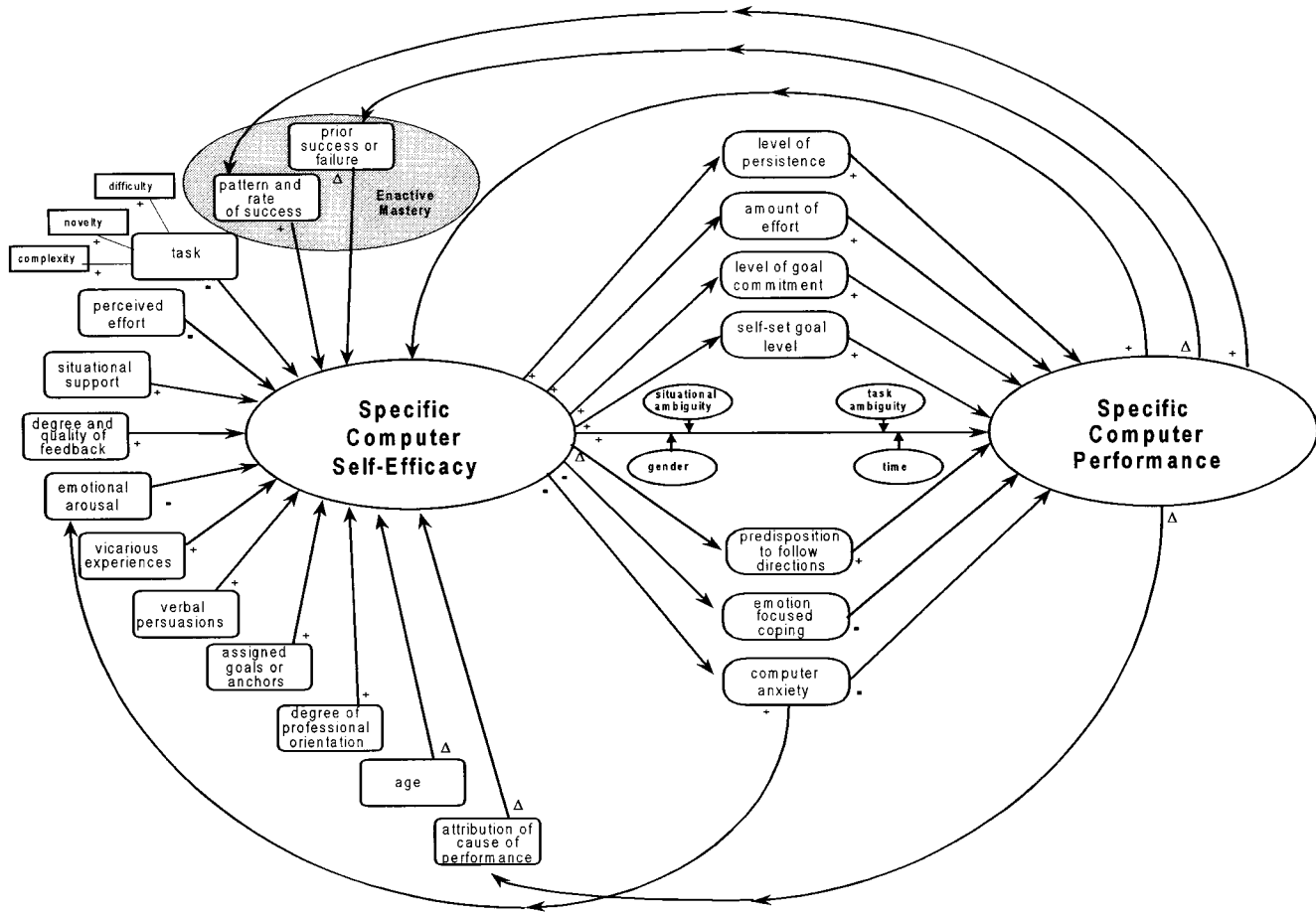
To more fully explain this differentiation, we have constructed a model of CSE (Figure 2) that is derived from empirical efforts in a wide variety of reference disciplines.³ The model clearly displays the multifaceted and reciprocal nature of the CSE-Performance relationship as well as the wide variety of known antecedent and consequent variables associated with the formation of CSE perceptions. Table 1 contains representative citations from the empirical literature to support each element in the model. We argue that to accurately measure or effectively manipulate the construct of CSE with the intention of drawing conclusions regarding the nature of the change in the perception, a conscious effort must be made by the researcher to identify and/or control the effects of all known antecedent or consequent factors associated with CSE.

Bandura's (1977b) original theoretical framework suggested four primary antecedent sources for self-efficacy judgments: (1) enactive mastery, (2) vicarious experience, (3) verbal persuasion, and (4) emotional

³All elements contained in the model of CSE have been empirically derived as a function of the study of the root construct of self-efficacy, from both within and external to any computer-specific task domains. In Table 1, wherever possible we have cited only the earliest empirical work for a particular factor. SE researchers contend that the theory can be extended to any knowledge domain without compromise (c.f. Gist and Mitchell 1992) and therefore, empirical evidence obtained in one knowledge domain should be generalizable and applicable in another. Given this, we do not differentiate between a variable derived from within or outside the computer task domain and assume the generalizability of SE-related findings to the CSE domain.

Figure 2 Multifaceted Model of Specific Computer Self-Efficacy

Legend: (+) Increase in factor results in **increase** in dependent variables. (–) Increase in factor results in **decrease** in dependent variable. (Δ) Relationship to dependent variable is **disordinal** in nature.



arousal. Bandura ordered these antecedent factors according to magnitude of effect with enactive mastery believed to be the strongest source of change and emotional arousal the weakest.

As can be seen from Figure 2, the original antecedent factors identified by Bandura are appropriately represented along with their known relationships to both SE and performance. The remaining antecedents shown in the model, however, do not appear to have received any significant collective attention anywhere in either SE or CSE literature.⁴

⁴Note that we have chosen to depict the various antecedent and con-

IV. Review of CSE Literature

Table 2 contains a comprehensive listing of the extant literature regarding CSE. For inclusion, each study had to meet three criteria: (1) a material focus on the CSE construct, (2) it either developed a measure or evalu-

sequent elements in the model without regard to either any implied order of importance or any possible correlations that may exist among them. While we acknowledge the possibility that one or more elements of the model may be correlated we do not believe that such possibilities would serve to alter either the nature of the relationships shown or the need to account and/or control for each of them.

Table 1 Empirical Literature Supporting CSE Model

Antecedent	Representative Work	Consequent	Representative Work
Enactive Mastery			
—prior success or failure	Bandura 1977a, 1977b	Predisposition to follow directions	Carlson and Grabowski 1992
—pattern/rate of success	Wood and Bandura 1989a	Self-set goal level	Taylor et al. 1984
Task characteristics	Cervone and Peake 1986	Level of goal commitment	Bandura and Cervone 1986
Perceived effort	Bandura et al. 1977	Amount of effort	Locke et al. 1984
Situation support	Bandura et al. 1977	Level of persistence	Bandura and Schunk 1981
Degree/quality of feedback	Dorwick 1983	Emotion-focused coping	Lent et al. 1987
Emotional arousal	Kavanagh and Bower 1985		Stumpf et al. 1987
	Lazarus and Folkman 1984	Computer anxiety	Glass and Knight 1988
Vicarious experience	Bandura 1977a and b, 1988		Meier 1985
Verbal persuasions	Bandura and Cervone 1986	<i>Moderating Variables to SE/Performance Relationship</i>	
Assigned goals/anchors	Cervone and Peake 1986	Gender	Miura 1987
	Stone 1994	Situational ambiguity	Eastman and Marziller 1984
Degree of professional orientation	Jorde-Bloom 1988	Task ambiguity	Cervone 1993
	Gist and Mitchell 1992	Time	Mitchell et al.
Age	Suls and Mullen 1982		1994
Attribution of cause	Schunk and Gunn 1986		Mone 1994

ated the construct as an independent variable (IV) or dependent variable (DV) of interest, and (3) it was published in a recognized academic journal or compendium. Studies were located via computer searches of large bibliographic databases and by scanning both published and unpublished sources. Upon completion, a total of 40 nonredundant papers were identified for inclusion.

In categorizing the studies, methodology, source of subject sample, and sample size are shown as initial characteristics. Additionally, given the findings regarding differences in CSE across gender,⁵ the gender breakdown of subjects is also reported for all but eight studies in which no information regarding gender mix was either provided or applicable. All IVs and DVs used in each study are reported, but the summary findings are limited only to those results directly related to

the CSE construct. For studies employing a survey methodology, no task description is provided. Studies where subjects performed a well-defined specific task (i.e., create a document using a specific application) are labeled as *single*. Where subjects performed tasks of a complex or multiskill nature (i.e., create a document using several applications) tasks are identified as *multiple*. The remaining tasks are identified either by indicating a focus on training or by a brief description of the task assigned. Also included is reference to the measures used to assess the CSE construct level of CSE measured (specific or general), number of elements in the measure, content, and measurement of strength and/or magnitude of the efficacy perception.⁶ Finally, information regarding the source of the instrument and any evidence of formal validation is provided. We have broadly defined formal validation to include evidence of any activities prior to administration such as

⁵Gender has been found to have a significant effect on initial levels of, and degree of change in, CSE. See section on gender for a more detailed discussion of the effect.

⁶A detailed discussion of the strength and magnitude dimensions of CSE is found in Section V.

Table 2 Chronological Summary Review of CSE Literature

Year	Cite	Method	<i>n</i>	No. M/F	Sample Source	IVs	DVs	Nature of Task	Source of CSE Instrument	CSE Measures	Findings
1985	Hill et al.	Survey 1 Survey 2	83 44	Not reported 0/44	Students Students	Product complexity, CSE, instrumentality, product description. GCSE	Purchase decision Purchase decision	N/A	Self-developed. Formal validation.	CSE content 7 items 6 pt. Likert GCSE content 4 items 5 pt. Likert strength only	Study 1: CSE was significantly related to complexity of technology. Study 2: CSE was negatively related to propensity to sign-up for free trial of a new software product.
1987	Hill et al.	Survey 1 Survey 2	304 133	147/157 0/133	Students Students	GCSE, computer experience, beliefs of benefits of computer use.	Behavioral intentions, Pre-enrollment in computer courses.	N/A	Self-developed. Formal validation.	GCSE content 4 items 5 pt. Likert strength only	Study 1 & 2: CSE significantly contributes to prediction of behavioral intentions. CSE is an important factor in determining an individual's decision to use computers. Experience is directly related to CSE and related to use through intentions.
1987	Mitura	Survey	368	104/264	Students	Gender, age, ed. level computer ownership, computer use.	GCSE, enrollment in computer science class.	N/A	Self-developed. Formal validation.	GCSE content 15 items 3 subscales magnitude: Y/N strength: 10-100	Males have higher CSE than females. Experience was highly correlated with CSE. Best predictors of CSE were education level, major, and past enrollment in computer course.
1988	Jorde-Bloom	Survey	80	9/71	Early education administrators	Gender, computer attitudes, innovativeness, computer experience, outside support, professional orientation.	Level of administrative tool and as classroom tool.	N/A	Self-developed. Only internal consistencies reported.	GCSE content # of items and reported magnitude: Y/N strength: 1-100	CSE significantly correlated with gender, professional orientation, outside support, and both DV's.
1988	Jorde-Bloom and Ford	Survey	80	9/71	Early education administrators	Gender, innovativeness, computer experience, profes- sional orientation, age, out- side support, outcome expectations, background in math & science.	Level of computer use as administrative tool and as classroom tool measured at 5 distinct levels.	N/A	Self-developed.	GCSE content 15 items magnitude: Y/N strength: 1-100	CSE significantly correlated with gender, professional orientation, innovativeness, experience, outside support, and both DV's.
1989	Gist et al.	Laboratory Experiment	108	41/67	University managers & administrators	GCSE, Video vs. interactive training.	CSE, performance, response to training, work style.	Single	Self-developed. Formal validation.	GCSE content 5 items CSE content 5 items Both used magnitude: Y/N Strength: 1-10	Behavioral modeling was significantly correlated with higher performance, higher CSE, more positive work styles, less negative affect during training, and greater satisfaction.

Table 2 Continued

Year	Cite	Method	n	No. M/F	Sample Source	IVs	DVs	Nature of Task	Source of CSE Instrument	CSE Measures	Findings
1989	Murphy et al.	Survey	414	Not reported	Graduate students and nurses	Gender, age, and computer experience.	GCSE	N/A	Self-developed. Formal validation.	GCSE content 32 items 5 pt. Likert strength only	CSE loaded on 3 unique factors: beginning, intermediate, and mainframe skills. Average male CSE was at 75% percentile in female CSE distribution.
1990	Burkhardt and Brass	Survey	81	Not reported	Federal employees	GCSE, prior training, age, education, computer attitudes.	Early adoption of computers.	3 different administrations of survey	Self-developed. No evidence of formal validation.	GCSE content 3 items 7 pt. Likert strength only	CSE findings represent a small part of a much larger study by authors. CSE was significantly correlated with early adoption, hours of training, and age.
1990	Ogletree and Williams	Survey	125	47/78	Students	Gender type, gender, computer ownership, experience, use, and education.	GCSE, computer attitudes, computer skill level.	N/A	Modified Mura(1987) SE Questionnaire. No evidence of formal validation.	GCSE content 15 items 5 pt. Likert strength only	CSE higher for males than females. When effects of experience and sex-typing were removed, gender differences on CSE and attitudes were no longer significant.
1991	Compeau and Higgins ICIS	Survey	1020	847/173	Professional knowledge workers	encouragement, use by others, org. support.	GCSE, outcome expectations, affect, computer anxiety, computer use.	N/A	Self-developed. Formal validation.	GCSE content 10 items magnitude: Y/N strength: 1-10	CSE, outcome expectations, affect, and computer anxiety all had a direct effect on computer use. CSE and outcome expectations indirectly affect use through affect and anxiety. Behavior and influence of others had a small influence on CSE and outcome expectations.
1991	Compeau and Higgins ASAC	Survey Pre Pilot Main	40 64 1020	Not reported 847/173	Professional knowledge workers	N/A	N/A	N/A	Self-developed. Formal validation.	GCSE content 10 items magnitude: Y/N strength: 1-10	Developed and tested a measure of CSE. Found significant positive relationships between CSE and outcome expectations, use, frequency of use, use at home, familiarity, training, and affect. CSE was negatively related to computer anxiety. (See Compeau and Higgins, 1995 MISQ)

Table 2 Continued

Year	Cite	Method	n	No. M/F	Sample Source	IVs	DVs	Nature of Task	Source of CSE Instrument	CSE Measures	Findings
1992	Carrison and Grabowski	Laboratory Experiment	57	16/41	ROTC students	GCSE, gender, membership in military training prog.	Direction-following behavior	single	Murphy, et al. (1989)	GCSE content 32 items 5 pt. Likert strength only	Higher CSE for males than females and for those in military training than those who were not. Interaction effect between CSE and gender on DV. Low CSE males follow directions less than high CSE males. This effect was opposite for females.
1992	Harrison and Rainer	Survey	693	Not reported	Salaried university personnel	GCSE, computer attitudes, computer anxiety.	None	N/A	Murphy et al. (1989). Formal validation.	GCSE content 32 items 3 sub-scales 5 pt. Likert strength only	Reliability measures were high for all instruments and subscales. CSE was negatively associated with anxiety and positively associated with attitudes.
1992	Martocchio	Survey Field Experiment	84 79	18/66 32/47	University clerical and administrative personnel	Threat versus opportunity label of microcomputer, computer experience.	GCSE, computer anxiety, learning.	N/A training task	Modified Hollenbeck and Brief (1987). Formal validation.	GCSE content 6 item scale 5 pt. Likert strength only	Study 1: Employees distinguish between threats and opportunities with respect to microcomputer use. Study 2: Anxiety was a negatively related antecedent to CSE. Expectation was a positively correlated antecedent to CSE. CSE was negatively related to learning.
1992	Martocchio and Webster	Field Experiment	68	7/61	University clerical and administrative personnel	Feedback, demographics, motivation to learn, computer anxiety, cognitive playfulness, CSE, computer experience, positive mood.	Post-training satisfaction, satisfaction with feedback, CSE, test performance.	W/P mail merge task	Modified Hollenbeck and Brief (1987). Formal validation.	CSE content 6 item scale 5 pt. Likert strength only	For positive feedback, no differences were found for performance attribution for each level of CSE. Both feedback and playfulness were significantly related to CSE. For low initial CSE, internal performance attributions were made. For high initial CSE, external attributions were made. Feedback direction was significantly related to CSE.
1992	Webster and Martocchio	Survey	Vari.	Vari.	Students and university personnel	N/A	N/A	N/A	Modified Hollenbeck and Brief (1987). Formal validation.	CSE content 6 item scale 5 pt. Likert strength only	Developed a measure of microcomputer playfulness using CSE as a criterion against which to assess measures of playfulness. Results indicated a positive relationship between CSE and playfulness.

Table 2 Continued

Year	Cite	Method	n	No. M/F	Sample Source	IVs	DVs	Nature of Task	Source of CSE Instrument	CSE Measures	Findings
1993	Delcourt and Kinzie	Survey	328	67/259	Students	Computer experience, computer use, computer attitudes, demographics.	CSE for word processing, e-mail, and data retrieval, computer attitudes.	N/A	Self-developed. Formal validation.	CSE 25 items 3 subscales 4 pt. Likert strength only	Internal consistencies for all subscales were high. Results were equivocal. Experience explained significant portion of variance in CSE across all subscales. Attitude was significant for word processing and e-mail but not for database.
1993	Olivier and Shapiro	Literature Review									Only known review of CSE literature to date. Relatively narrow in both scope and discussion.
1993	Webster and Martocchio	Field Experiment	68	8/60	University clerical and administrative personnel	Labeling of training, age, CSE, anxiety, computer attitudes, motivation, expectations, computer experience.	Post-training motivation, test performance.	Training and test	Modified Hollenbeck and Brief (1987). Formal validation.	CSE content 6 item scale 5 pt. Likert strength only	CSE was used as a control measure to determine the degree of differences between two treatment groups prior to a training manipulation.
1994	Ermer et al.	Field Experiment	32	19/13	Students	Use of e-mail vs. word processing.	CSE, computer attitudes.	multiple	Delcourt and Kinzie (1993) Computer Technologies Survey (CTS) Form B.	CSE content 46 items 4 pt. Likert 6 subscales strength only	Strong interaction between time and CSE. Experience on one system tends to increase CSE on other related systems. Significant difference in pre-test CSE between W/P and e-mail disappeared in post-test.
1994	Henry and Stone	Survey	384	84/300	Hospital workers	Mgmt. support, ease of use, computer experience.	GCSE, outcome expectancy, job satisfaction	N/A	Self-developed. Formal validation.	GCSE content 3 items 5 pt. Likert strength only	All IV's had significant effects on CSE. CSE moderates their effect on job satisfaction and on outcome expectancy. Similar to Henry and Stone, 1995.
1994	Kinzie et al.	Survey	359	97/262	Students	Computer use, computer attitudes, course experiences, demographics.	CSE for word processing, e-mail, data retrieval, spreadsheet, statistics software, and DBMS.	N/A	Modified Delcourt and Kinzie, 1993. Formal validation.	CSE content 46 items 4 pt. Likert 6 subscales strength only	Internal consistencies for all subscales were high. CSE was significantly correlated with experience. Attitudes contributed significantly to prediction of CSE after effects for experience and demographics were removed.

Table 2 Continued

Year	Cite	Method	<i>n</i>	No. M/F	Sample Source	IVs	DVs	Nature of Task	Source of CSE Instrument	CSE Measures	Findings
1994	Martocchio	Field Experiment	76	36/40	University service and administrative personnel	Induced conception of ability.	GCSE, computer anxiety, knowledge.	Training and test	Modified Hollenbeck and Brief (1987). Formal validation.	GCSE content 6 item scale 5 pt. Likert strength only	For static ability conceptions, CSE drops with experience. For acquirable skill, CSE increases with experience. Though related to performance, CSE did not mediate relationship between ability conception and performance. Older subjects showed a decrease in CSE for static condition over younger subjects.
1994	Martocchio and Dulebohn	Field Experiment	86	23/63	University full-time employees	Feedback, demographics, software experience.	CSE, compilation, positive mood, knowledge, goal commitment.	Training and task	Modified Hollenbeck and Brief (1987). Formal validation.	CSE content 6 item scale 5 pt. Likert strength only	Subjects who received feedback that attributed performance to internal factors had higher CSE than those who received external attribution feedback. CSE was significantly correlated with experience.
1994	Mitchell et al.	Laboratory Experiment	110	56/54	Students	CSE, goals, expected performance, cognitive effort.	Performance over 7 trials.	Computer simulation	Self-developed. No evidence of formal validation.	GCSE content 11 items 10 pt. Likert strength only	Cognitive effort with regard to task processing and CSE estimations decreases with experience. On early trials CSE is a better predictor of performance than either expected performance or goals. This relationship reversed itself in later trials.
1994	Russon et al.	Laboratory Experiment	20	0/20	Students	Instruction method analogy vs. traditional	GCSE, performance, # of requests for help.	Single	Self-developed. No evidence of formal validation.	GCSE content 27 items 2 subscales 10 pt. Likert strength only	Change in CSE related to instructional methods positive but not significant yet all subjects reported task easier than expected. Analogy instruction method was significantly better than traditional in terms of performance measures. Strong correlation between CSE and # of requests for help.

Table 2 Continued

Year	Cite	Method	n	No. M/F	Sample Source	IVs	DVs	Nature of Task	Source of CSE Instrument	CSE Measures	Findings
1994	Smith	Field Experiment	148	59/89	Students	Instruction method, verbal persuasion, gender.	CSE, GCSE	Multiple	Self-developed for CSE. Formal validation. Modified the Hill et al. (1987) for GCSE.	CSE content 16 items GCSE content 16 items Both used magnitude: Y/N strength: 0 or 100	All groups experienced CSE and GCSE increases but results were equivocal. Some were significant, some were not. No significant main effect for gender but interaction between gender and group was significant. Change in CSE strength and magnitude explained 55% and 40% of the variance in GCSE respectively.
1994	Torkzadeh and Koufteros	Field Experiment	224	125/99	Students	Computer training	GCSE	Multiple	Modified Murphy et al. (1989). Formal validation.	GCSE content 32 items 3 subscales 5 pt. Likert strength only	Participation in computer training increased CSE for both genders. Evidence of significant gender differences equivocal across subscales.
1995	Busch	Survey	147	67/80	Students	Gender, prev. experience, encouragement, task complexity.	CSE, computer attitudes.	N/A	Self-developed. Formal validation.	CSE content 20 items 5 pt. Likert strength only	CSE and computer attitudes are highly correlated. CSE was related to experience across all task levels. Males displayed higher initial CSE for complex tasks.
1995 b	Compeau and Higgins ISR	Laboratory Experiment	88	43/45	Managers and professionals	Prior performance, training method.	GCSE and CSE, outcome expectancy, performance.	2 day training and task	Modified Compeau and Higgins (1991) ICIS	GCSE and CSE content 8 items magnitude: Y/N strength: 1-10	Results were mixed. CSE was consistently related to personal outcome expectancy across all groups. Behavior modeling significant for S/S (+) and for WP (-). CSE significantly related to performance in some groups and not others. Prior performance significantly related only with day 2 S/S group.

Table 2 Continued

Year	Cite	Method	n	No. M/F	Sample Source	IVs	DVs	Nature of Task	Source of CSE Instrument	CSE Measures	Findings
1995 a	Compeau and Higgins MISO	Survey	1020	847/173	Professional knowledge workers	Encouragement, use by others, org. support.	GCSE, outcome expectations, affect, computer anxiety, computer use.	N/A	Self-developed. Formal validation.	GCSE content 10 items magnitude: Y/N strength: 1-10	Developed and tested a measure of CSE. Found significant positive relationships between CSE and outcome expectations, use, frequency of use, use at home, familiarity, training and affect. CSE was negatively related to computer anxiety. (See Compeau and Higgins 1991 ASAC)
1995	Henderson et al.	Survey	107	9/98	Purses - 62 clerical - 45	GCSE, occupational group.	GCSE, computer attitudes, expectations, level of distress.	N/A	Loyd and Gressard (1984) Computer Attitude Scale (CAS) Confidence subscale	GCSE content 10 items 5 pt. Likert strength only	Nurses had lower CSE, less positive attitudes, and more negative expectations of MIS than clerical workers with experience held constant. CSE as IV explained 72% of variance in anxiety. CSE positively related to experience and negatively related to anxiety.
1995	Henry and Stone	Survey	524	372/152	Hospital staff members	Mgmt. support, ease of use, computer experience.	GCSE, outcome expectancy, job satisfaction.	N/A	Self-developed. Formal validation.	GCSE content 3 items 5 pt. Likert strength only	All IVs had significant effects on CSE. CSE had a significant effect on job satisfaction but not on outcome expectancy.
1995	Igbaria and Iivari	Survey	450	241/209	Employees of 86 largest firms in Finland	Computer experience, org. support, industry, functional area.	GCSE, computer anxiety, ease of use, usefulness, system use.	N/A	Modified Hill et al. (1987). No evidence of formal validation.	GCSE content 2 items 5 pt. Likert strength only	Experience and organizational support have a significant effect on CSE. CSE is related negatively to anxiety and positively to ease of use. There was no evidence of a direct effect of CSE on system use. CSE operates on actual usage through ease of use. No significant effects due to industry or functional area.

Table 2 Continued

Year	Cite	Method	n	No. M/F	Sample Source	IVs	DVs	Nature of Task	Source of CSE Instrument	CSE Measures	Findings
1995	Taylor and Todd	Survey	786	Not reported	Students	Ease of use, usefulness, peer influence, superior's influence, GCSE, facilitating conditions for resources and technology.	Computer attitudes, subjective norms, behavioral control and intention, usage behavior.	N/A	Modified Compeau and Higgins (1997) ASAC. Formal validation.	GCSE content 3 items magnitude: Y/N strength: 1-10	Path models were tested for all variables. CSE was shown to have a significant impact on perceived behavioral control.
1995	Webster and Martocchio	Field Experiment	143	49/94	University clerical and administrative personnel	Training preview, CSE, playfulness.	Attention to performance eval., flow, learning, satisfaction, post-training reaction.	Training and test	Modified Hollenbeck and Brief (1987). Formal validation.	CSE content 6 item scale 5 pt. Likert strength only	CSE significantly influenced learning and post-training reactions but did not significantly relate to trainee satisfaction either directly or indirectly.
1996	Venkatesh and Davis	Laboratory Experiment	36	Not reported	Students	GCSE, objective usability.	Ease of use.	Survey and training	Compeau and Higgins (1995) MISQ	GCSE content 10 items magnitude: Y/N strength: 1-10	CSE did not change with experience or over time in either study and is positioned as an antecedent to ease of use.
1996	Marakas et al.	Field Experiment	220	127/93	Undergraduate students from Intro to Computing course	CSE and GCSE	Task performance	Survey, training, and single/multiple tasks	Self-developed. Formal validation.	GCSE 7 items. CSE 7-10 items depending upon application magnitude: Y/N strength: 1-10	Research-in-progress. Initial findings indicated divergent validity in CSE/GCSE measures, support for hypothesized temporal relationship b/t CSE and GCSE, and isolation of levels of CSE and GCSE.

Table 2 Continued

Year	Cite	Method	n	No. M/F	Sample Source	IVs	DVs	Nature of Task	Source of CSE Instrument	CSE Measures	Findings
1996	Torkzadeh et al.	Survey and factor analysis	199	Not reported	Undergraduate students from Intro to IS course	N/A	N/A	Survey	Torkzadeh and Koufteros (1994)—modified Murphy, et al. (1989) formal validation	GCSE 30 items 5-point Likert strength only.	Using LISREL, compared Torkzadeh and Koufteros (1994) 4 factor solution with Murphy, et al. (1989) 3 factor solution. Four factor found a better fit (beginning skills, file and s/w skills, advanced skills, & mainframe skills. Eight items, however, showed r-squared <0.50. Hinted at suggestion of a higher-order factor.
1996	Torkzadeh and Pflughoeft	Field experiment	414	212/212	Undergraduate students from Intro to IS course	Intro Training	GCSE	Survey	Torkzadeh and Koufteros (1994)—modified Murphy et al. (1989) formal validation	GCSE 30 items 5-point Likert strength only.	Student demonstrated higher levels of GCSE at the end of the semester than measured at the beginning of the semester. These findings suggest GCSE as a higher-order factor to specific CSE factors.

pilot testing, assessment of internal consistency, divergent and/or convergent validity, and comparison to other measures.

Observations and Analysis

The present body of research into the CSE construct does not lend itself to any meaningful quantitative, meta-analytic approach based upon combining results and effect sizes from multiple studies. The focus of the empirical work to date has been quite broadbrushed and reports on a wide variety of relationships. As such, our approach is more one of a qualitative discussion and review of the findings. It is important to note that, except where specifically stated, no suggestion is being made that any of the empirical efforts to date in CSE should be in any way discounted due to absences or imbalances in the various antecedent and consequent variables. Rather, we suggest that such absences or imbalances could serve to magnify, diminish, or confound the effects or relationships noted and that these issues should be given careful scrutiny when interpreting past results or when contemplating the design of new studies. The essence of our position is that if we are to gain insight into the true effects of manipulations intended to enhance CSE, we must pay careful attention to those factors that have known significant influences on pre/post levels of GSE.

Comparison to the Model

In the interest of both clarity and conciseness, we have chosen to structure our comparison of the CSE literature to the model in Figure 2 by grouping the various factors and issues as follows:

- Initial or Prior Performance Characteristics, and Attribution of Cause
 - Task Characteristics and Situational Support
 - Perceived Effort and Persistence
- Vicarious Experience, Verbal Persuasion, and Feedback
 - Computer Anxiety, Emotional Arousal, and Emotion-Focused Coping
 - Assigned/Self-Set Goals, Anchors, and Goal Commitment
 - Gender
 - Age
 - Time
 - Direction Following Behavior

- Professional Orientation
- Issues of CSE Measurement
- Issues of CSE Manipulation

Initial or Prior Performance Characteristics, and Attribution of Cause

The relationship between SE and task performance has been well established in the empirical literature of several IS reference disciplines. Numerous studies have reported significant correlations between the level of subject SE and subsequent task performance (Bandura 1982, Bandura and Adams 1977, Bandura et al. 1977, Locke et al. 1984, Gist and Mitchell 1992, Mitchell et al. 1994, Compeau and Higgins 1995b). The value of this relationship to training efforts in general, and computer training programs in specific, cannot be understated. As shown in the model of CSE, the relationship between CSE and performance is of a reciprocal nature. In early trials of a new task, as CSE is increased, performance at the specific task level is improved. As the pattern and rate of successes improves, the model of GCSE suggests that levels of both CSE and GCSE increase, thus manifesting improvement at the overall domain level as well. This reciprocity continues through later trials until the task is believed to be mastered by the individual such that he or she no longer actively performs an effortful, conscious analysis of CSE. At this point, the individual tends to shift to a more simple estimation process based primarily on past performance (Mitchell et al. 1994). "After people develop adequate ways of managing situations that recur regularly they act on their perceived efficacy without requiring continuing directive or reflective thought," (Bandura 1997, p. 55). When this simpler processing of CSE begins to occur, the relationship between CSE and performance degrades in terms of predictability (Mone 1994). We argue it is at this point that GCSE may become the more salient predictor of future performance levels at both the general and, possibly, task-specific levels.

While the SE-Performance relationship has been well established in the literature, it has also been found to be both disordinal and more complex than Bandura's original propositions. Bandura (1988) acknowledges that theories surrounding the estimation of individual efficacies owe an intellectual debt to attribution theory (cf. Kelley 1971, Kelley and Michela

1980).⁷ "The factors singled out by attribution theory serve as conveyors of efficacy-related information that influence performance attainments mainly by altering people's beliefs in their efficacy," (p. 38). The *attribution* placed by the subject on the cause of the most recent performance can serve to disordinally alter the subsequent estimations of CSE (Silver et al. 1995). Several such attributional determinants include effort, ability, luck, task difficulty, intellectual level, health, and mood. While each of these can serve to affect CSE estimations directly, they can also be perceived to be reasons for a particular performance outcome. In these cases, the attribution of cause of performance success or failure can become a salient factor in subsequent SE estimations (Schunk and Gunn 1986).

Wood and Bandura (1989a, 1989b) found that both the *pattern of success* and the *rate of perceived successful performances* can independently and collectively serve to alter the SE-Performance relationship. Building upon prior studies (Dweck and Elliot 1983, Nichols 1984), they induced conceptions of ability in their subjects as either *stable* (performance is regarded as diagnostic of fixed intellectual capacity) or *acquirable* (performance is regarded as a function of ability that can be continually enhanced). They hypothesized that the conception of ability with which people approach complex intellectual tasks is likely to have a significant impact on the various self-regulatory influences, including SE estimation, that govern performance. Their findings showed that those subjects who viewed their performance as a part of skill acquisition in which one learns from their mistakes were not adversely affected by substandard performances with regard to subsequent estimations of SE. Conversely, following a substandard performance, those subjects who construed their performance as being a diagnostic of underlying intellectual capacities substantially reduced their subsequent estimations of SE. These findings have been further supported empirically within the CSE domain by Martocchio and Dulebohn (1994) and Martocchio (1994). It is quite possible, given the unique nature of

the computer knowledge domain, that attributions of performance may not be formulated as easily or as clearly categorized (i.e., stable versus acquirable) as they might be in a more familiar setting. CSE research must include a focus on how skill development within the computer domain might be perceived differently than from within other noncomputer-related domains.

Of the 40 studies CSE studies identified, 11 employed some form of enactive mastery as the DV.⁸ In all cases, the performance measure was based on the subject's demonstration of mastery of a skill, or skills, acquired during a prior training session. Analysis of the available information regarding pre/post test measures taken in CSE studies indicates that inconsistent attention has been paid, however, to the effect of prior experience or attribution of performance on changes in CSE. Four studies were found that identified attribution of cause as a measured or manipulated variable (Mitchell et al. 1994, Martocchio 1994 and 1994b, Martocchio and Dulebohn 1994). Further, while half (20) of the studies provided some indication of use of prior experience as either an independent or control variable, the operationalization of prior experience was found to be inconsistent across many of the studies identified.

Within the identified studies, prior experience measures ranged from perceptual measures of individual subject ability (Compeau and Higgins 1995b) to several questions intended to determine any significant differences across groups (Delcourt and Kinzie 1993, Murphy et al. 1989) to formal assessments of pre-test skill level intended to be used in comparison with other post-test measures (Henry and Stone 1994, Martocchio 1992, Ogletree and Williams 1990, Busch 1995). In all studies where prior experience was assessed pre-test a significant correlation with prior experience was found with both CSE and actual performance.

The strength of the CSE-performance relationship must be given careful consideration when designing a manipulation of CSE. The presence of task-relevant experience gained pre-test must be ascertained and, if present, used as a control variable if any meaningful

⁷Attribution theory suggests that your perception of a stimuli will depend to a large extent on whether you attribute the observed behavior to internal causes (e.g., abilities, motives, or traits) or to external causes (e.g., luck or situational factors.)

⁸Appendix A contains a complete list of all CSE literature listed according to the model classifications used herein.

measure of change in CSE is to be made and attributed to the manipulation at hand. Further, care must be taken to either control or account for the effect of enactive mastery on CSE induced as a direct result of the experimental design. If multiple tasks, or multiple occurrences of the same task are used during the course of a manipulation of CSE, then each instance must be recognized as an enactive mastery event and must, therefore, be accounted for in any measured change in CSE from pre-test to post-test. As an example, Compeau and Higgins (1995b) chose to collect a single pre-test perceptual measure of experience from each subject rather than assess the skill set of the subject using a more objective measure. The equivocal nature of their findings over the two days suggests that one or more confounds, such as pre-test or mid-treatment experience, may have made analysis of the data problematic. In short, if any meaningful conclusion regarding the effect of a specific manipulation or training approach is to be directly tied to a change in CSE, then all effects of pre-test experience or manipulation-induced experience as well as individual subject attributions of cause must be parceled out of the measured change.

Task Characteristics and Situational Support

Several researchers have shown that task characteristics such as perceived difficulty, novelty, ambiguity, or complexity can, independently of other situational factors, have a direct effect on the formation of perceptions of self-efficacy. Campbell (1988) and Wood (1986) both found that the number of component parts involved in completing a task and the sequential steps required to perform it successfully both had direct effects on the formation of SE perceptions. Cervone (1985) demonstrated that when subjects were asked to focus on the more formidable aspects of a task, their self-efficacy was lowered. Conversely, subject SE was increased simply by having them focus on the less overwhelming, more doable aspects of the task.

Task ambiguities can include inaccurate or ambiguous feedback, ill-defined performance levels (Eastman and Marzillier 1984), or external factors (e.g., geographic location or task interdependence) that appear to affect CSE indirectly through their influence on internal variables (e.g., behavioral and psychological

strategies, personality traits, or mood) (Gist and Mitchell 1992). Bandura (1986) argues that individuals must have some idea of the performances they are seeking to attain. In the presence of task ambiguities, subjects "are at a loss to know how much effort to mobilize, how long to sustain it, and when to make corrective adjustments in their strategies," (p. 398). While conceptually related to performance feedback, task ambiguity is focused more on the lack of a priori definitions of outcomes. When subjects are not aiming for anything in particular, feedback no longer produces useful information and there exists little basis for translating estimations of SE into appropriate levels of effort.

Along these same lines, both pre-test and post-test measures relating to subject perceptions of task ambiguity are necessary. Myriad computer training experiences can be made available to enhance the skill set of an individual or an entire organization. Without a clear understanding of the relevance of a particular skill as well as the nature of the expected task outcome related to such skill acquisition, the subject may form relatively high estimations of CSE that are not translatable into any meaningful (or possibly measurable) levels of performance.

Bandura (1986) posits that disincentives to act upon one's self-perceptions of efficacy can arise as a result of the situation in which the perception is formed or the degree of ambiguity associated with the task at hand. If a lack of necessary equipment or resources to perform the behavior adequately is present, then judgments of CSE might often exceed the actual performance. Despite the situation, however, subjects might nonetheless believe they have the ability to perform well given the right tools or resources. Further, the task environment itself may influence CSE estimates (Gist and Mitchell 1992). Characteristics such as noise, auditory or visual distractions, interruptions, physical or psychological danger, the geographical setting, or even the weather can all serve contingently to affect the formation of initial CSE estimates (Lazarus and Folkman 1984). Yet another situational variable may be the particular method employed in training an individual to perform a specific computer-related task (i.e., video-based training versus lecture). If the pedagogy is perceived by the individual to be difficult to follow or

ineffectual in reaching its stated goals, his or her estimates of CSE could be negatively affected.

Post-test measures of situational support should be taken to determine the degree to which each subject might attribute environmental conditions to his or her performance. These measures should include subject perceptions regarding the appropriateness of the training approach or pedagogy employed. We cannot assume that either positive or negative change in CSE is the result of the specific training method without having some insight into the subject's perception of issues relating to situation support.

Our review found no evidence of any studies that controlled for or measured specific task characteristics and only one study that manipulated task complexity and situational support (Russon et al. 1994). Three additional studies were identified that measured situational support during pre-test (Henry and Stone 1994, Igbaria and Iivari 1995, Jorde-Bloom 1988). No material evidence was found, however, suggesting the existence of manipulation checks intended to determine the individual subject's focus on particular tasks characteristics related to complexity, ambiguity, or difficulty of their perception of level of support. While this lack of information does not allow us to conclude that such issues were not addressed in a specific study, it does allow for the assumption that such issues have not generally been deemed relevant to the interpretation of the results. Given such evidence in the literature of other domains, we recommend that future CSE research be cognizant of the effect of task characteristics and situational support on formation of CSE estimates and provide information regarding their treatment and/or control.

Perceived Effort and Persistence

Bandura and Cervone (1983, 1986) found a significant relationship between level of SE and both subject persistence toward completion of the task and general effort expended. Further, they posited that SE perceptions contribute to individual motivation across a wide variety of discrepancy conditions. The results of numerous empirical efforts across widely diverse domains for both children and adults corroborate their findings by demonstrating that a strong belief in one's SE heightens perseverance and effort in difficult task

situations (Brown and Inouye 1978, Cervone and Peake 1986, Bandura 1986, Bandura and Schunk 1981, Schunk 1984). Intuitively, therefore, cognitive judgments of the amount of effort necessary to complete a computer-related task could serve to affect both the pre-experience and post-experience formations of CSE. Bandura et al. (1977) demonstrated this empirically within the domain of phobia reduction. Using adult snake-phobics as subjects, the sequence of behavioral tasks presented to the subjects was ordered by relative level of threat. The subjects either continued in their attempts to complete the entire set of tasks or chose to quit at varying points during the performance evaluation based on their perception of the effort necessary to complete the next task. The perseverance of the subject, as measured by the number of tasks successfully complete, was highly correlated to both the pretest and interim measures of self-efficacy. While all subjects completed the majority of low-threat tasks, only those with a high level of initial and interim SE chose to expend the effort to successfully complete the higher threat tasks. These results suggest that the amount of effort expended in prior experiences or the amount perceived to be necessary in a pending task can significantly affect the estimation of SE across individuals.

It is important to note, however, that the relationships between increases in CSE and effort or persistence might be more complex than they appear intuitively. Bandura and Cervone (1986) found that knowledge of having accomplished a high level of achievement through intense effort or persistence did *not* automatically serve to increase SE or raise subjects' aspirations. While some subjects did respond to their achievements with a subsequent increase in SE, others displayed self-doubts regarding their ability to repeat the same level of effort. "Having driven themselves to success, a number of performers judged themselves inefficacious to repeat the demanding feat and lowered their aspirations," (Bandura and Cervone 1986, p. 110). This suggests that across individuals there exist varying threshold levels of effort and persistence in their relationships to self-efficacy that, when exceeded, can serve to alter the predictability of outcomes. We will revisit this question as it relates to estimations of CSE during our discussion of the relationship between CSE and goal-related issues.

The CSE literature is silent with regard to measures of perceived effort or persistence related to the task presented to the subjects. If the task presented to the subjects is novel (assumption of no significant prior enactive mastery) then estimations of perceived effort must be recorded and used as a control variable in determining the actual change in CSE. If, however, the task is familiar, then both pre-test and post-test measures of perceived effort must be taken. The pre-test measure will serve as a baseline for the initial estimation of CSE while the post-test will allow for analysis of any change in perceived effort that may have resulted from the training manipulation or task experience. Insight into specific components of the training directly related to degree of difficulty can then be reviewed for modification and/or redesign that will reduce the effect of perceived degree of difficulty on future estimations of CSE.

Vicarious Experience, Verbal Persuasion, and Feedback

Bandura (1977a, 1977b, 1986) suggested that people partly judge their capabilities in comparison with others. This judgment is highly dependent upon the salience of the task, the model, the environment, and even the positional power of the trainer. Further, such comparisons may be made through either observational, verbal, or direct feedback channels or any combination thereof. The application of these components of SLT to the development of training methods intended to enhance CSE appears to be increasingly attractive (Compeau and Higgins 1995b, Gist et al. 1989, Simon 1995, Henry and Stone 1995, Busch 1995, Martocchio and Webster 1992, Smith 1994, Hill et al. 1985, Martocchio and Dulebohn 1994). Despite this attractiveness, however, several studies have shown that behavior modeling through vicarious, verbal, or feedback channels is a complex task requiring careful consideration of the costs versus the benefits.

For example, Bandura and Cervone (1983) clearly point out the importance of understanding that neither direct mastery without clearly defined standards of performance nor established standards without some form of direct mastery will provide a sufficient basis for effective SE formation. Further, Russell et al. (1984) found evidence to suggest that behavioral modeling

without the proper establishment of both performance standards and direct mastery experiences is not effective in any long-term behavior change. They concluded that any training involving vicarious experience as the primary manipulation should be immediately followed by both active goal setting exercises and reinforcement in an actual setting if positive transfer is to be realized. Implicit here is that manipulation of CSE via vicarious experience channels should focus on techniques that employ vicarious experience to deliver performance standards combined with direct mastery experiences that reinforce them.

While several studies in our review acknowledged the value of vicarious experience in the manipulation of CSE only three (Hill et al. 1985, Gist et al. 1989, Compeau and Higgins 1995b) provided evidence of inclusion of the technique in the research design. Hill et al. (1985) obtained results suggesting that subjects with initially low levels of CSE who saw "experts" demonstrate various typewriting, word-processing, or computing technologies were more easily persuaded to sign up for a trial adoption of the product than those who did not receive their experience vicariously through an "expert." Gist et al. (1989) did not find support for their hypothesized interaction between training condition and CSE. Subjects with low initial CSE did perform better in the modeling condition than in the tutorial condition but no more so than those subjects with moderate and high initial CSE levels. They posited that conceivably some of the low CSE subjects were intimidated by the model's flawless performance. "Perhaps, observing a model who occasionally stumbles, but recovers and successfully completes the task, might facilitate identification, vicarious learning, and training performance for low computer self-efficacy trainee in the modeling condition" (p. 888). Compeau and Higgins (1995b) used a modeling videotape as a vicarious experience manipulation during their two-day study. While their results did not provide conclusive evidence of the value of the vicarious experience manipulation there was evidence to suggest that a portion of the variance in CSE and performance could be attributed to the training manipulation. With the exception of Gist et al. (1989), however, issues with regard to salience of the model or the scenario were not addressed or ascertained. We discuss these points in

greater detail in the section devoted to CSE manipulation.

Related to vicarious experience is verbal persuasion. When viewed as support or encouragement, as opposed to direct or subtle pressure to perform, this factor can have increased informative value in enhancing CSE (Killian 1985). As with vicarious experience, however, verbal manipulations must be considered by the subject to be both salient and congruent with other sources of CSE estimation if they are to be effective. Gist (1987) suggests that expertness and credibility of the source, consensus among multiple sources, and evidence of familiarity of the source with task demands can all serve to affect the success of verbal persuasion in manipulating CSE.

In the context of computer training and subsequent use, simply telling a person that development of a new set of computer-related skills is within their ability does not mean that person will believe it, particularly if it contradicts personal experience. Those users who have encountered negative computer-related experiences in the past will be hesitant to embrace new applications or computer skill development. Further, if specific verbal persuasions do serve to encourage adoption or acceptance of new computer activities and the subsequent experience is negative, the salience of the source of persuasion along with any related sources will be significantly reduced in future estimations. Reliable estimations of CSE must be derived from more than vicarious or verbal channels alone.

Four studies were identified that either measured or made direct use of verbal persuasion in the manipulation of CSE. Both Busch (1995) and Henry and Stone (1995) measured pre-test verbal persuasion (in the form of previous encouragement and management support, respectively) and found significant relationships between degree of verbal persuasion and subsequent formation of computer attitudes and levels of CSE. Hill et al. (1985) used verbal persuasion in combination with vicarious experience to manipulate subjects' CSE and decision to adopt a complex technology. Finally, Smith (1994) used verbal persuasion in combination with a traditional lecture training method to manipulate CSE. Their results showed significant in-

creases in CSE over the course of the semester-long experiment but there was no conclusive evidence suggesting that verbal persuasion had any direct effect on the change in CSE. A closer look at the study reveals an extreme imbalance in gender across the two verbal persuasion treatment groups that could account for the lack of definitive results. This gender effect will be discussed in greater detail shortly.

A third channel of comparison to others in the estimation of CSE is via internal and/or external feedback mechanisms. Feedback clarifies the various person-performance contingencies that may be used in the formation and revision of CSE percepts (Gist and Mitchell 1992). Bandura (1986) suggests that individuals create cognitive images of efficacious action that tend to guide their behavior and function as *internal* standards for change. Dorwick (1983) empirically demonstrated the direct effect of *external* feedback on the formation of SE percepts. Subjects exhibiting deficient skills were assisted (through a variety of mechanisms) to perform at levels that exceeded their usual accomplishments. A videotape of the subject's performance was then edited to remove all instances of any hesitations, mistakes, or external aiding mechanisms. After observing the edited videotaped successes, the subjects displayed substantial increases in performance level compared to other nonobserved baseline activities. Conversely, performance levels were able to be reduced simply by showing the subject only the defective portions of their performances. Later, Gonzales and Dorwick (1983) found that by splicing favorable endings to otherwise errant performances they were able to produce measurable differences in self-observed actual skillfulness. The implication of these findings suggests that CSE may be affected via feedback mechanisms that promote self-modeling.

Martocchio and his colleagues (Martocchio and Webster 1992, Martocchio and Dulebohn 1994) have studied the direct effects of various feedback mechanisms on changes in CSE. Their findings support the results obtained in other domains suggesting that positive feedback can be a powerful mechanism in raising levels of CSE and negative forms of feedback can be equally influential in reducing levels of CSE while si-

multaneously affecting internal performance attributions.

Bandura and Cervone (1984) found a strong relationship between negative feedback and low SE evaluations. Although some subjects actually increased their efforts as a result of the negative feedback, others became noticeably demoralized and showed significant decreases in SE. Admittedly, further research is needed to determine the conditions under which distortions in SE perceptions may arise from feedback (Gist 1987) but sufficient evidence exists to suggest that feedback must be accounted for and/or controlled in any manipulation of CSE.

Regardless of the direction of manipulation, however, comparison channel techniques intended to increase SE estimates carry with them certain practical and ethical considerations (Bandura and Cervone 1983, 1986). Eden and Kinnar (1991) argue that it is inappropriate to artificially raise an individual's CSE to a level that exceeds their true ability through comparison channels alone. They suggest that misleading underqualified candidates is harmful to both the individual and to the organization. Artificially raising the expectation of subjects' CSE to levels that motivate them to impart extreme effort into a demanding task can have effects opposite that which are intended. Bandura and Cervone (1986) demonstrated that knowledge of having surpassed a demanding standard through laborious effort did not automatically strengthen perceived SE and raise aspirations. A number of subjects, after having driven themselves to success, judged themselves inefficacious to repeat the demanding feat and subsequently lowered their aspirations. The issue here is that performance motivation is not a monotonically increasing function of degree of perceived discrepancy. "Performances that fall markedly short of standards are apt to give rise to discouragement and goal abandonment" (Bandura and Cervone 1983, p. 1017). An important issue for CSE researchers to consider is the threshold strength value below which reduced CSE or possibly GCSE results in goal abandonment. Such thresholds must be both determined and monitored during comparison channel manipulations to avoid reductions in subject motivation due to reductions in channel salience or credibility.

Computer Anxiety, Emotional Arousal, and Emotion-Focused Coping

There exists a reciprocal relationship between computer anxiety, CSE estimation, and subsequent levels of emotional arousal. The link between emotional arousal and its negative effect on SE formation is widely accepted in the literature (Kavanaugh and Bower 1985, Lazarus and Folkman 1984). People partly rely on their state of psychological and physiological arousal in forming judgments of their level of anxiety or vulnerability to stress (Bandura et al. 1977). Since high levels of arousal are often associated with reduced computer performance (Gutek and Winter 1990), subjects are more apt to consider themselves capable when they are not beset by aversive arousal. Further, it has been shown that anxieties experienced by subjects in relation to a task performance situation tend to generate further anxiety through the process of anticipatory self-arousal (Bandura 1977a, Sarason 1975, Rosen et al. 1987). This cycle of anxiety in a computer setting can become measurably debilitating and can serve to increase resistance to, fear of, or even aggression toward computers (Weil et al. 1990, Marakas 1994, Marakas and Hornik 1996).

An extensive amount of research has been done to ascertain the source and nature of anxieties about present or future interactions with computer-related technologies.⁹ Results from several studies (i.e., Bloom and Hautaluoma 1990, Weil et al. 1987) have shown, contrary to expectations, treatments such as repeated exposure to the computer or employment of "user friendly" software do not serve to reduce computer anxiety in high arousal subjects but instead often result in significant increases. Social Learning Theory suggests that repeated exposure to the computer in the absence of *direct anxiety-reducing mechanisms* serves to *recondition* the computerphobic at increased levels of anxiety which, in turn, increase emotional arousal. This cycle of negative enactive situations serves only to exacerbate the level of computer anxiety rather than cure it. As such, subsequent estimations of CSE are negatively impacted by this spiraling, seemingly unending, cycle of anxiety-producing experiences with a computer.

⁹Glass and Knight (1988), Meier (1985), and Weil et al. (1990) provide extensive reviews of computerphobia literature.

Nine studies contained in the review provided direct evidence or acknowledgment of the effect of computer anxiety or emotional arousal on the change in CSE. Four of the studies positioned both computer anxiety and CSE as DV's (Martocchio 1992, 1994; Igbaria and Iivari 1995; Henderson et al. 1995), two used the ease of use construct (Davis et al. 1989) as a surrogate for emotional arousal with CSE positioned as a DV (Henry and Stone 1994, 1995), one positioned anxiety as an IV with CSE as the DV (Kinzie et al. 1994), and the remaining two positioned both CSE and computer anxiety as IVs (Martocchio and Webster 1992, Harrison and Rainer 1992). Where anxiety was positioned as the IV, the expected negative relationship with performance found strong support. Further, all the studies found strong support for the negative relationship between emotional arousal and CSE.

Related to these emotional affectors of CSE is the degree to which a subject proactively employs strategies intended to cope with the anxieties present. Bandura (1977b) states that "expectations of personal mastery affect both initiation and persistence of coping behavior. The strength of people's convictions in their own effectiveness is likely to affect whether they will even try to cope with given situations" (p. 193). Building upon this, Stumpf et al. (1987) found that SE expectations had a significant negative effect on emotion-focused coping ($r = -0.34$). The model suggests, therefore, that manipulations intended to reduce emotion-focused coping behavior must be performed in parallel with those intended to effect increases in CSE. Such combined manipulations should result in generally higher levels of psychological well-being and less diversion of psychological energy toward coping with emotional disturbances associated with the computer-related task or situation. We cannot assume that an increase in level of CSE alone will be sufficient to overcome all latent anxieties or emotional arousals commonly found in new computer users.

Both Weil et al. (1987) and Bloom and Hautaluoma (1990) have employed anxiety management techniques and training to successfully reduce levels of computer anxiety in subjects. Though not directly referring to either SLT or the construct of self-efficacy, their techniques closely resemble those employed by Bandura and his colleagues for the purpose of increasing levels

of SE in severe phobics. Somewhat counterintuitive, however, is the apparent lack of global recognition by the CSE literature of the importance of the anxiety relationship and by the computerphobia literature of the potential value of CSE manipulation and enhancement in reducing anxiety. Nonetheless, we argue that the two streams of research are highly complementary and should be given careful consideration within the realm of future CSE research.

Assigned/Self-Set Goals, Anchors, and Goal Commitment

Empirical evidence suggests that since initial estimates of SE (pre-performance of a novel task) are made under uncertainty they may be influenced by a number of goal-related factors. Locke et al. (1984) found that SE was positively related to goal level ($r = 0.59$ and 0.57 for SE strength and magnitude, respectively). Several studies have shown that subjects with higher levels of SE tend to set higher initial goals for themselves (Bandura and Cervone 1986, Taylor et al. 1984). Locke et al. (1984) also found a significant relationship between SE and goal commitment for those subjects with self-set goals ($r = 0.30$). This effect was powerful even after controlling for subject ability and past performance.

Another goal-related influence to estimations of CSE is the introduction of anchor values that are not related to any actual event or performance level. Latham and Locke (1991) posit that those "who are assigned challenging goals are more likely to have high self-efficacy than those who are assigned low goals since assigning high goals is in itself an expression of confidence" (p. 221).

A compelling example of this effect can be found in the work of Cervone and Peake (1986). Their objective was to manipulate SE independent of either training or differential information about the task. Subjects were described a task composed of a series basic mathematical or logical actions ordered by increasing level of complexity. They were then given index cards numbered from 1 to 20 and asked to place them in a cloth bag to facilitate their seemingly random selection of one as their assigned goal. Unbeknownst to the subjects, however, the cards they drew actually were pre-arranged (via a hidden compartment in the cloth bag)

to be either a 4 or an 18. After the subject drew the "random" number, the experimenter asked each subject to indicate whether he or she felt they could do more than, less than, or equal to the number drawn. This response was recorded along with the subject's initial assessment of how many items of the task set they thought they were capable of completing. In virtually all cases, subjects receiving the high anchor value displayed higher levels of SE than did those who received no anchor, who in turn displayed higher levels of SE judgments than did those subjects receiving the low anchor. These results demonstrate that a prior nonexperiential anchor value in the form of an assigned goal can have a powerful effect on SE perceptions. Additionally, the resultant SE perceptions were significantly related to corresponding differences in behavioral persistence. Cervone and Peake (1986) suggest that other heuristics such as availability¹⁰ (Tversky and Kahneman 1973, 1974) could also have relevance in the formation of SE perceptions, but to date no empirical work in this area has been published.

The importance of this prior anchoring effect on estimations of CSE is related to the construction of instruments intended to measure the construct as well as the design of training mechanisms intended to enhance it. Manipulations that are intended to establish a higher initial anchor might prove useful in raising the initial levels of CSE in subjects that are known to demonstrate initially low levels due to negative past experiences, gender, or other characteristics such as age. In contrast, however, unintended sources of anchors such as an inappropriate ordering of items on an instrument, or of task segments incorrectly implying increasing complexity where none exists, may serve to confound the relationship between changes in CSE and measured levels of performance. These issues are discussed in later section devoted to issues of measurement of CSE.

We were able to find but one CSE study that included any goal-related variables in its design. Martocchio and Dulebohn (1994) hypothesized positive relationships between goal commitment and feedback, perceived controllability, and CSE. Further, their

¹⁰The availability heuristic suggests that individuals assess the probability of an event by the ease with which past instances or relevant associations come to mind. Highly available past experiences suggestive of success might serve to enhance SE.

study included the use of a number of known antecedents to CSE, such as age, gender, and prior experience, as control variables intended to better isolate the constructs of interest, and thus the hypothesized relationships therein. Notable among their results was the strong relationship found between CSE and goal commitment ($p < 0.001$).

Gender

While the majority of the CSE studies reviewed either explicitly or implicitly acknowledged the known relationship between CSE and gender, one notable characteristic among them was the profound imbalance of subjects with regard to gender. There is substantial evidence suggesting that females are typically more risk-averse and show lower levels of initial CSE than males (Jorde-Bloom 1988, Miura 1987, Murphy et al. 1989). Ogletree and Williams (1990), however, found that when the effects of specific computer experience and sex-typing¹¹ variables were removed, the common male/female comparisons on SE estimations were no longer significant. The salient gender-related factor in SE estimation was found to be degree of subject masculinity/femininity rather than biological gender per se. Further, Arch and Cummins (1989) found that among freshmen at a small, private college who were required to make regular use of computers to complete papers, initial gender differences in both attitudes and expectations disappeared. For those students, however, where computer access and use was simply available but not mandated, the gender differences were actually exacerbated during the semester. Implicit here is that unless the task situation is highly structured, individuals with a feminine or soft mastery style may be less likely to approach computer interaction situations and may be more apt to formulate lower estimations of CSE despite successful performance experiences.

From our review, we find that eleven of the studies used a female-dominant subject mix that exceeded 1:1.5, with five of those studies employing a mix in excess of 1:5. Further, five studies used a male-dominant sample in excess of 1.5:1, with four of the

¹¹Sex typing refers to the process of rewarding and punishing appropriate or inappropriate sex role behavior during adolescence (Mischel 1970).

five in excess of 4.5:1. Given the strength of the empirical findings regarding the effects of gender and sex-typing on CSE, we argue that this demographic imbalance could confound accurate pre/post measures of CSE. In addition, because the effect has been shown to favor an initially lower CSE for females than males, this condition could result in largely inflated reported effect sizes due to training or enactive manipulations. In male-dominant mixes the reported gains, if any, could be understated. Murphy et al. (1989) estimated a relative gender effect size where the average male stands at about the 75th percentile in the female distribution of CSE.

As an example, the study conducted by Henderson et al. (1995) had as its stated objective the assessment of occupational differences on a number of psychological variables (including CSE) associated with MIS success. In addition, computer anxiety was also stated as a primary concern. The sample was divided according to reported occupation and classified as either clerical or nursing and no differences between groups were reported for all demographic variables. Discussed in greater detail below, empirical evidence has been found to suggest that a significant relationship exists between professional orientation and CSE (Jorde-Bloom 1988, Jorde-Bloom and Ford 1988). Thus, given this dichotomization of subjects, prior research suggests that the nurses will display higher initial levels of CSE and lower initial levels of computer anxiety. Counterintuitively, however, the exact opposite was found. The clerical subjects had significantly higher levels of CSE and the professional subjects displayed very high initial levels of anxiety combined with lower levels of CSE.

In discussion, the researchers noted the surprising nature of their findings and concluded that their results may be explained by differences in computer experience across the two groups. While the clerical group did have more prior experience with computers than the nursing group, this factor was held constant in the analysis of the data. The authors concluded that the relationships between experience and the psychological variables of interest must not be either simple or static.

While we agree in principle with the conclusions of

Henderson et al. regarding the complexity of the experience-CSE relationship, a closer analysis of their study suggests a possible source of confound that could further assist in explaining their findings. While there were no significant differences *across groups* with regard to gender the sample was, nonetheless, *within group* heavily imbalanced with female subjects (92% female). Given the known gender effect associated with CSE, it is possible that the responses to the questionnaire were influenced such that the expected relationships between professional orientation and CSE and the measured levels of anxiety and CSE were rendered uninterpretable within the scope of the underlying theory.

Age

Bandura (1986) offers a theoretical explanation of the effect of age on SE perceptions: "In cultures that revere youth and negatively stereotype the elderly, age becomes a salient dimension for self-evaluation" (p. 418). While longitudinal studies reveal no general or widespread deterioration in intellectual abilities until a very advanced age, cross-sectional comparisons of various age groups suggest otherwise (Baltes and Labouvie 1973). Schaie (1974) found that the young do surpass the old in intellect primarily because of differences in experiences across generations rather than any biological aging. Suls and Mullen (1982) have shown that the elderly tend to evaluate their performance attainments by comparing them to their level of functioning at an earlier period in their life. As such, age can contribute to an over or underconfidence condition with regard to the initial formation of CSE perceptions. The effect has been often lamented from a computer technology perspective and these results suggest that two conditions may be of importance: (1) a decline in CSE associated with age, or (2) an initial low CSE relative to younger subjects of similar experience is apt to set in motion a self-perpetuating decline in both cognitive and behavioral functioning toward computers.

Several studies in our review acknowledged age as an important variable affecting CSE and its subsequent relationships, although certain equivocalities exist. Specifically, Burkhardt and Brass (1990) found a significant negative relationship ($r = -0.23$; $p < 0.05$) between CSE and age, and Kinzie et al. (1994) found a

significant but somewhat weaker effect while Webster and Martocchio (1993) found no effect. Similar equivocalities exist within the review between those who found age to be a significant antecedent to CSE (Martocchio 1994, Martocchio and Dulebohn 1994) and those who did not (Jorde-Bloom 1988, Jorde-Bloom and Ford 1988). Interestingly, however, a closer inspection of the studies reveals that those who found a significant age-CSE relationship tended to display a balance between male and female subjects, whereas those who did not find significance tended to be highly gender imbalanced. This suggests the possibility that the strength of the gender effect regarding CSE might serve to mask other known effects of lesser effect size.

Time

Mone (1994) suggests that little is known about how either the antecedent or consequent factors related to SE estimations change over time. He argues that strong positive relationships between static levels of SE, personal goals, and performance are not necessarily equivalent to relationships between dynamic levels of these same variables. Kanfer and Ackerman (1989) found evidence suggesting that the resources that people use as they learn to perform a task (e.g., cognitive abilities or effort expenditures) will change substantially over time. From this, it appears reasonable to assume that the predictive power of CSE estimations for changes in specific computer performance should be expected to deteriorate over time. Using a computer-based skill acquisition task, Mitchell et al. (1994) found that SE was a better predictor of performance than goals in early trials. Once the task was learned, however, performance expectations and goals became significantly better predictors of subsequent performance than SE estimates. Upon further investigation, they found that, over time, subjects were simply considering fewer factors in their SE estimates, especially factors reflecting direct feedback from the task. We concur with Gist and Mitchell's (1992) suggestion that "greater conceptualization is needed about the plasticity of the determinants of SE: the specific causal factors that are susceptible to change, the extent of probable change, and the practical issues involved in facilitating change" (p. 184). Ertmer et al. (1994) found a significant relationship between time and levels of CSE as

well as evidence suggesting that increases in CSE in one computer-related task tend to have a positive effect on initial levels of CSE for other system-specific tasks. In keeping with this, initial results from recent research suggest that the temporal deterioration of the CSE-Performance relationship may be related to the conceptualized relationship of GCSE as a function of a series of domain-specific CSE estimations as shown in Figure 1 (Marakas et al. 1996).

Direction-Following Behavior

Carlson and Grabowski (1992) found a significant interaction effect between CSE and gender by direction-following behavior. On the surface, they concluded that males and females have different direction-following behaviors based on their level of CSE. What is of greater importance here, however, is the *disordinal relationship* found between direction-following behavior and CSE. Intuitively, an individual with low CSE should be expected to more carefully read and follow directions given the implied lack of confidence in his or her abilities with the computer. Interestingly however, in the Carlson and Grabowski study this was true only for females. The males were found to behave exactly opposite. The results suggested that the males with low CSE were ambivalent toward the directions and tended to proceed through the instructional exercise without much concern. From a computer training perspective, if direction-following behavior is a critical element to a particular learning process then the interaction between gender and CSE should be given careful consideration.

Professional Orientation

Jorde-Bloom (1988) and Jorde-Bloom and Ford (1988) focused attention on the computer self-efficacy perceptions of early childhood administrators and their relationship to pioneering behavior with regard to adoption of microcomputers in elementary education programs. Both hypothesized a number of relationships between CSE and level of use, previous computer experience, gender, level of education in math and science, and *degree of professional orientation* (defined as a role perception variable influenced by various sociodemographic characteristics of the administrator).¹² While CSE was found to be a significant

¹²Professional orientation influences included level of education, in-

contributor to the explained variance in adoption of computers for administrative purposes and the majority contributor for instructional purposes ($r^2 = 0.16$ and 0.37 , respectively), the data also provided strong support for the hypothesis that professional orientation is positively associated with level of CSE ($r = 0.60$). This suggests that the sociodemographic characteristics of the subject must be taken into consideration when measuring or manipulating computer self-efficacy in either a controlled or an applied setting.

In addition to the work of Jorde-Bloom and her colleagues, two additional studies contained within the CSE review are relevant here as well. Both Henderson et al. (1995) (see discussion under section on gender above) and Harrison and Rainer (1992) reported the collection of data indicating a categorization of subjects across levels of professional orientation. While the former reported results opposite those of Jorde-Bloom, the latter identified the cross-sectional nature of their sample with regard to professional orientation as notable yet failed to provide any results focusing on any differences in CSE related to specific personnel categories. We encourage future research to both actively seek out diverse professional groups such as those used by Harrison and Rainer and conduct useful analyses on the relationships between CSE and the various levels of professional orientation.

V. Measurement and Manipulation of CSE

Despite the seemingly infinite domains within which estimations of self-efficacy can be formed and the wide variety of proposed instruments, there are a limited number of methods available to effectively measure the construct. Given close inspection, most methods of measurement that have been shown effective are derived from Bandura's (1986) original guidelines for measuring SE.

The approach suggested by Bandura (1986) requires the individual to respond dichotomously to whether

he or she is capable of performing at one or more levels on a *specific* task. The sum of the positive, or "yes," responses is considered to represent the *magnitude* of that individual's specific self-efficacy. Each affirmative response collected during magnitude measurement is then rated by the subject on a scale that ranges from either 1 or 10 (quite uncertain) to 100 (quite certain) at intervals of either 1 or 10 points, respectively. The sum of these confidence ratings is used as a measure of SE *strength*. The two scores are then correlated with performance measures across subjects.

In a recent study, Lee and Bobko (1994) compared five methods of measuring SE commonly found in the literature. They found the most common method of assessment was to use only strength measures (cf. Bandura and Jourden 1991, Wood and Bandura 1989a, Brown et al. 1989), with the second most common method employed being the use of only magnitude measures (cf. Cervone and Palmer 1990, Peake and Cervone 1989). Of the remaining three methods, two were versions of a combination measure between SE strength and magnitude, and the last was a single-item measure (cf. Clement 1987, Kerr 1989).

Lee and Bobko found the single-item measure to demonstrate the least convergent validity and correlation to performance and the two combination indices to be the strongest and most consistent measures. The correlation between performance and the measure of SE remained strong when derived from a combination of SE strength and SE magnitude.

From our review, we find 19 of the 40 studies classified as employing a self-developed measure of CSE with the remaining studies using an existing instrument, often with some modification. Only 6 of the 19 self-developed instruments did not evidence any formal validation procedures. This suggests that a measurable level of credibility can be ascribed to the CSE instruments presently in use. There are, however, several issues regarding their content and application that should be noted.

Twenty-five of the 40 studies listed used a CSE measure that was unidimensional in nature. In all cases, these studies measured only the strength (confidence) dimension of the subject's CSE estimation. As reported by Lee and Bobko (1994), measures of SE that are unidimensional in nature do not demonstrate the consistency and strength of correlation to performance of

come, social status, type, and range of both on-the-job and outside activities pursued by the administrator. In addition, organizational size and structure were also considered in this assessment.

those measures utilizing a combination of SE strength and magnitude. We argue that given the theoretical foundation of the construct as one of multidimensionality, a measure of CSE must account for both the strength and magnitude of the estimation if it is to be valid.

In interpreting the correlations between performance and measures of CSE we must be guided by both the roots of the theory and, in some cases, by simple logic. While strong correlations provide for clear interpretation, moderate or low correlations may provide several avenues of explanation. One possible explanation is that the theory is wrong. This prospect is never without some merit in any research endeavor but, in most cases, can be reconciled by comparison to prior research efforts and by close scrutiny to the research methods employed. A second possibility is that the measure of CSE is not strongly related to the task being performed. An typical example of this would be a computer-related task involving chance or luck, rather than acquirable skills. In this situation, no measure of CSE will be correlated over several trials with performance. A third possible interpretation is that in the presence of a new task domain that is unfamiliar to a subject, the assessment of CSE may be problematic and subject to greater variance. Our model suggests that certain factors such as age, task characteristics, causal attributions, emotion-focused coping or computer anxiety could become dominant in computer-related tasks presented to subjects with little or no prior experience in the domain. Under these conditions, CSE measures may not appear to be strongly correlated with performance outcomes in early trials.

Following this, and in keeping with our multilevel definition of CSE, we suggest that a possible fourth explanation for low or moderate correlations to performance can be found in the differences between the CSE construct at the specific and general levels. Both Sherer et al. (1982) and Eden and Kinnar (1991) point out that measures of specific self-efficacy do not explain the perpetually high motivation of someone who maintains consistently high expectations of SE across a wide variety of task situations, nor the chronically low motivation that results from constant low expectations. We believe that GCSE represents a cognition about a general self-competence that is developed over

time and through a collective of domain-related experiences. As such, any measure of it must be correlated with a measure of domain-related general, rather than task-specific, performance. Much of the CSE research to date has been designed such that the performance feedback and measures are predominantly *task-specific*. The majority of the instruments used to assess pre- and post-task CSE, however, are often more focused on a general rather than task-specific level of analysis. As with any attempt to correlate antecedent with outcome, the more closely related conceptually the predictor is to the criterion, the more valid the measure potentially becomes (Mone and Kelly 1994). Mitchell et al. (1994) argue that it comes down simply to whether one is interested in prediction as opposed to attempting to understand and to explain how and why one is able to predict.

Recall that Bandura (1986) identifies the third dimension of the SE construct to be that of *generality*. This dimension focuses on the degree to which one task-specific self-efficacy estimation generalizes to other domain-related estimations. We have argued for a distinction between the general and task-specific levels of CSE and have offered several justifications for this position. Following the work of Locke et al. (1984) and Eden and Kinnar (1991), we reason that a lack of parallelism between the level at which the CSE construct is measured and the level at which the performance is measured could result in weak or questionable results.

Question Construction

In keeping with our suggestions regarding parallelism in measurement and isolation of the construct of interest we offer a simple framework for the development of instruments intended to measure CSE. As with our model of CSE, the basis for each component of the framework is rooted within the theoretical and empirical literature related to the construct. Table 3 contains the components of the framework:

Focus on Subject Ability. The definition of CSE as a perception of an individual's ability to perform a specific task suggests that any measurement be constructed in terms of particularized judgments by the subject on his or her ability to perform the required task rather than on any related benefits or outcomes resulting from the performance. "The item content of

Table 3 Framework for the Construction of CSE Measuring Instruments

- All questions must **focus on the subject's perceived ability** to perform a specific task without regard to outcome expectations or derived benefits.
- All questions must elicit estimations of ability within a **task-specific rather than a general context**.
- Specific questions must **avoid** ability assessments that include **cross-domain or general-domain skills**.
- The **level of analysis (LOA)** of the requested estimation of perceived ability **must agree** with the level of analysis of the task and subsequent performance measure.
- The ordering of questions must **avoid inappropriate or unnecessary anchoring** with regard to perceived rather than actual increasing levels of task difficulty or complexity.

self-efficacy scores must represent beliefs about personal capabilities to produce specified levels of performance and not include other characteristics" (Bandura 1997, p. 73). Estimations of ability to perform must be isolated from expectancies of the potential outcomes or rewards associated with performing well. An individual's estimation of his or her ability to perform a specific computer-related task is not, and should not, be related to his or her belief that doing so will result in desirable outcomes. Consider the following:

"An efficacy expectation is a judgment of one's ability to execute a certain behavior pattern, whereas an outcome expectation is a judgment of the likely consequences such behavior will produce. The expectation that one can jump six feet is an efficacy judgment; the social, recognition, applause, trophies, and self-satisfactions anticipated for such a performance constitute the outcome judgments" (Bandura 1978b, p. 240).

Task-Specific Context, Cross-Domain Skills, and Level of Analysis. As above, the definition of the construct is that of an estimation of ability to perform a specific task rather than to perform within a generalized domain of tasks. While recent research reflects a move toward the identification and measurement of both a specific and a general level of computer efficacy, the degree of specificity of the ability estimation must nonetheless be driven by the specificity of the task. If a subject is asked to estimate his or her ability to perform a skill that can be applied in a variety of task situations within the knowledge domain of computer use then that subject's estimation of CSE will be formulated more at the general level than the task-specific

level. Further, if a subject is asked to estimate his or her ability regarding a computer-related task that requires significant skills from outside the computing domain then the isolation of the CSE construct will be impaired. The outcome of this lack of parallelism will be a weakening in the observed relationship between CSE and performance as well as a reduction in the predictability of future task-specific performance based on prior measures of CSE. As such, if the task performance measure is specific in nature then the questions must be constructed such that the subject is focused only on his or her ability within that specific task context if any interpretable results are to be obtained.

Avoiding Inappropriate or Unnecessary Anchoring. Bandura (1997) points out that while every set of items relating to the measurement of SE must begin somewhere, the preferred format is one that minimizes any anchoring influence. The items should be ordered randomly such that no inappropriate inference regarding increasing task complexity is present. Ideally, several sequences of the items should be tested during development and validation for the presence of order or anchoring bias. Berry et al (1989) found that ordering questions in descending order of implied complexity produced higher SE estimations than either ascending or random ordering. In addition, the work of Cervone and Peake (1986; discussed previously) points out the ease with which SE estimations can be manipulated via initial anchor values.

A review of the studies listed reveals several examples relevant to the component parts of the above framework. Russon et al (1994) used a self-developed measure of GCSE content to assess the effects of analogy versus traditional computer instruction methods. The task given to the subjects was the duplication of a one-page letter using a specific software package. The results showed no significant difference between the two training methods, although the hypothesized direction was found. We believe this lack of significance may be attributable to, or at the very least exacerbated by, a number of deviations from the proposed framework. Evidence of this is found in a description of their CSE instrument:

"... consisted of two types of items ... The first type (13 items) assessed self-efficacy in relation to familiar computer

tasks that could be encountered in daily experience (e.g., deposit money via bank machine, program a VCR for immediate then delayed recording, find a library book's code and location via computerized catalogs, use a microwave oven for immediate then programmed cooking, program a photocopier for 20 reduced copies). The second type (14 items) concerned more specialized computer tasks encountered at work or school (e.g., complete an introductory university computing course with C+ grades, start a computer using its manual, alter instructions to print one instead of four pages, write a letter via a word processor, use packages to calculate income tax or analyze data, learn a programming language, "debug" a program, write a program to sort book names alphabetically)" (p. 181).

Based on the above description, it appears that several potential confounds could be introduced into their results simply by the content of the instrument. The seemingly arbitrary dichotomization of tasks into groups of "familiar daily life" and "specialized work or school" imparts a lack of parallelism by construction. Further, many of the items within each classification are either questionable as to their inclusion within a computer-skills domain (i.e., deposit money via a bank machine) or cross-domain in nature (i.e., use packages to calculate income tax or analyze data). Additionally, their results could have been further confounded by the extreme gender imbalance of their subjects: zero males and twenty females. In this situation, it is possible that any significant effects of the training mechanisms on raising the levels of subject CSE (a condition that should be enhanced by the female-dominant mix) were masked by the lack of parallelism between the pre-task measure of GCSE and the specificity of the performance task.

Similar illustrations of this situation can be found in the works of Compeau and Higgins (1995b) and Webster and Martocchio (1992, 1993, 1995). In the Compeau and Higgins (1995b) study a measure of CSE was used that focused on the degree to which the subject believed he or she could perform a previously unexperienced task (under a variety of assistance scenarios) using a software package (Lotus 1-2-3 or WordPerfect). A close inspection of the instrument used suggests a possible lack of isolation of the CSE construct. The construction of the CSE measure asks inexperienced subjects to estimate the likelihood of

completing an unspecified software task using a specific software package under several contextual conditions such as availability of human support, access to help files, or unlimited time. Despite the inclusion of a specific software package within each question stem, we suggest that this measure is constructed to be simultaneously task-independent and context-specific, thus uncertain in nature. Further, we believe the context and framing of each question to be both independent and mutually exclusive of those suggested by each of the other questions thus creating difficulty in arriving at a comprehensive measure of CSE. We illustrate these concerns through direct reference to the study.

Over the two day study, the subjects were given either a series of specific spreadsheet tasks or specific word-processing tasks to complete. On the second day, the tasks were reversed depending upon which software the subject received on day one. Inconsistent with the relationship suggested by SLT, Compeau and Higgins obtained mixed results indicating that CSE was significantly related to performance in some groups and not others. We suggest that one possible explanation for the equivocality of their findings could be that the CSE measure was focused on events independent of the actual assigned task rather than specific ability assessments necessary to perform the assigned tasks. For example, the question stem for each item "I could complete **the job using (software application) . . . (emphasis added)**" **focuses the subject away from any specific computer ability assessment. Depending upon what "the job" is defined to be, the resulting ability assessment could display significant variance within and across subjects. Further, the individual question predicates are constructed to impart one or more unique conditions to the task scenario. Each calls for an estimation of successful completion that could easily be interpreted to be independent** of all other condition sets. ". . . if I could call someone for help if I got stuck," and ". . . if there was no one around to tell me what to do as I go," are both independent and mutually exclusive events that require context-specific estimations of outcome. As such, the combining of these independent estimations into a single measure of CSE does not intuitively appear feasible. Evidence of support for this explanation is found in the

singularly consistent finding of the study: CSE was significantly related to personal outcome expectancy across all treatment groups ($p < 0.05$) but equivocally related to performance (p ranging from <0.05 to n.s.). This finding suggests that a greater fit exists between the measured outcome expectancies of the subjects with regard to performing the task than their individual or collective estimations of CSE with regard to their ability.

As another example, the work of Webster and Martocchio has made consistent use over a variety of studies of a measure of CSE adapted from the work of Hollenbeck and Brief (1987). The instrument does not use a common question stem as with Compeau and Higgins but rather asks a series of questions related by the inclusion of a software application name into each sentence (e.g., "I expect to become very proficient in the use of "; "Using is probably something I will be good at."). In this case, the individual question items appear to focus the respondent more on expected outcomes than on individual estimations of ability to perform a specific task and, therefore, do not suggest appropriate isolation of the CSE construct.

CSE Manipulation

Bandura (1986) argues that any estimation of ability and the behavioral test with which it is being correlated should be administered closely in time. The temporal change in CSE measures is not yet understood; any undue delay between the pre-task measure of CSE (the actual performance measure) and any post-hoc CSE measure could result in moderate or weak correlations and, consequently, difficulty in interpretation or prediction. When considering a manipulation intended to produce a change in CSE, several issues must be examined. Following Gist and Mitchell (1992), we argue that any or all of several distinct factors can serve to influence the degree of any change in CSE.

First, CSE measures are subject to a *level effect*. Increases in CSE are subject to ceiling effects when pre-test CSE is already high. In other words, once a certain level of CSE is attained, further manipulations yield smaller changes in subsequent estimations. Additionally, *variability* can affect changes in CSE. Many work tasks require knowledge and skills that must be learned over time through extensive training. In the

presence of such tasks, if ability becomes more important than effort, generation of any immediate changes in CSE will be limited. If, however, performance is primarily resource sensitive (e.g., effort, persistence, goal commitment) then immediate changes in CSE could lead to immediate performance increases.

A third factor affecting changes in CSE is *locus*. Two individuals can have distinctly different levels of a particular determinant or weight that factor differently in the extent to which the individual perceives it contributing to performance. It becomes logical to assume, then, that the same measure of CSE can result from a wide variety of combinations of determinants, weights, and values assigned during estimation. From this, an intervention designed to enhance CSE in a particular computer task situation through training and task knowledge could yield significant improvement in one subject and not the other. Similarly, an intervention designed to increase intentions to expend effort could increase CSE in those subjects with low variability and high internal locus but not necessarily in others with a different combination of factors. It is plausible that a change in the mean level of CSE could lead to a change in the mean level of performance across subjects. The more highly variable internal determinants, however, are those that should lead to the most immediate and noticeable changes in CSE and performance *within* subjects. This suggests that measuring the change in CSE across subjects may not be as revealing of the true effect of a particular manipulation as a within subjects approach. This micro-analytic approach is in keeping with Bandura's (1977a, 1977b, 1982, 1986) original conceptualization of the self-efficacy construct and is explicitly more aligned with the demonstrated complexity of the antecedent and consequent factors associated with the CSE construct.

A fourth factor that can affect changes in CSE is *controllability*. The more an individual believes the causes of performance to be uncontrollable (weather, situation, physical fitness), the lower and more resistant to change will be their estimations of CSE. Related to this is the issue of attribution of cause. Storms and McCaul (1976) established the possibility of an *exacerbation cycle* with regard to SE and attribution. They argued that in the face of success most subjects, regardless of their pretask level of SE, would attribute their

successes to the presence of ability. But in the presence of failure a disordinal relationship is encountered. Subjects high in SE tend to attribute the performance to insufficient effort or bad luck, while low SE subjects tend to attribute the performance to lack of ability. Storms and McCaul posit that because ability is generally perceived to be a stable determinant of performance, those with low SE may actually experience declines in SE estimations with subsequent trials, thus exacerbating the decline in SE.

As another example of the controllability issue, Salomon (1984) argues that above and beyond the cognitive activities a specific source of information activates or inhibits in learners, the depth with which that information is processed might actually depend on the way in which it is perceived and on the qualities that are correctly or erroneously attributed to it. He demonstrated that most children perceive themselves to have a higher efficacy with regard to acquiring information from television rather than from print. As such, they tended to place less effort in the learning process associated with a new skill when presented with essentially comparable information via TV rather than print. Salomon suggests that the amount of effort expended must be differentiated from its qualitative nature. The implication for research into CSE, then, must be to establish the conditions under which a particular group of subjects will deeply process a learning task rather than simply to present the task using the most convenient or obvious media. Failure to pay careful attention to this issue could result in the commitment of resources to ineffectual training mechanisms intended to increase CSE and performance.

One final notable characteristic of the CSE research to date is the degree to which CSE is positioned as an IV versus DV. Across all applicable studies in the listing shown in Table 2, CSE appears 12 times as an IV and 22 times as a DV. This observation suggests that research to date has been more interested in those factors that can influence changes in CSE rather than CSE as either a moderator or antecedent variable. One plausible explanation of this is the strength of the most common relationship positioning CSE as an antecedent variable: that of the SE-performance relationship. It is widely accepted that CSE plays a major role in

determining performance levels and, therefore, it appears intuitively appealing to explore methods intended to enhance the level of CSE rather than to study its effects on other dependent variables. From our model of CSE (Figure 2), it can be seen that we position several potentially important factors as both consequences of changes in CSE level and mediators of the CSE-performance relationship. From this, we argue that while continued empirical efforts into better understanding the antecedents to CSE are certainly warranted, increased efforts into understanding the complex mechanisms and relationships that result in increased levels of performance relating to changes in CSE are also of significant value.

VI. Discussion and Conclusions

The CSE literature to date has made significant inroads into our understanding of the nature of the construct and its value to a variety of computer-related activities. It is important to note that we are not arguing for the lack of acknowledgment within the CSE literature of the multilevel or multidimensional nature of CSE as the sole source of equivocality or contradiction in any empirical findings. In fact, we believe that a number of possible issues such as a lack of congruence regarding the definition of the construct in terms of use versus ability, lack of a common conceptual framework to guide CSE research, or the as yet unknown temporal nature of the construct, among others, could each, or all, be contributory to some of the findings within the CSE literature. Exploration of each of these areas is clearly a monumental research effort and is beyond the scope of this paper. We simply believe that in addition to other areas of inquiry, the importance of pursuing a rigorous investigation into the CSE construct at both the general and task-specific levels is of significant value. We believe that such an approach carries with it several implications of potentially consequential worth.

The speed with which the information technology of today and tomorrow is becoming a mainstay in our daily lives speaks to the importance of increasing computer skills across all individuals. Research to date has shown computer skill to be an important determinant in computer use, employee placement and advancement, selection, education, training, and hardware and

software support (Harrison and Rainer 1992). Along with the development of these skills, however, comes both satisfaction and anxiety. It requires a strong sense of efficacy to deploy one's cognitive resources optimally and to remain task-focused and goal-oriented in the face of repeated difficulties and failures. Wood and Bandura (1989a) posit that those who judge themselves to be inefficacious in coping with the demands of their environment tend to become more self-diagnostic (concerned with one's personal ability to perform) than task-diagnostic (concerned with the necessary actions to complete the task). Implicit here is the role of CSE in facilitating the introduction of computers into all levels of the organization and its continuing role in focusing the cognitive resources of the workforce on the task rather than on themselves.

The cost of employee training is quite high and will continue to become more costly. Our knowledge of the relationship between CSE enhancement and subsequent performance must be refined beyond its present form if we are to reap the benefits of incorporating CSE manipulation into our corporate training programs. We need to develop a greater understanding of the differences among individuals of high CSE versus those with lower percepts of computer ability. High CSE trainees might differ significantly from low CSE employees in not only the type of training method best suited to increasing their performance but also to the degree to which the training becomes effectual. Training mechanisms intended to increase CSE must be targeted to those who will most benefit rather than applied in a uniform manner that could be beneficial in some while wasting valuable corporate resources in others.

Along these same lines, we need to determine whether there exists a practical limit of attainment to the level of CSE at either the general or specific levels. Is there a ceiling beyond which an employee is no longer a candidate for continued GCSE enhancement? If so, what are the practical problems associated with informing employees with high GCSE of the reason why they are being excluded from certain training programs while others are not?

We know individuals are often reluctant to risk trading established imperfect order for potential disorder.

As such, the common reaction to potential change carries with it a distinctly conservative thrust. Increasing CSE through both experience and knowledge may help to temper the potential negative attitudes often associated with the introduction of computers into an environment.

Also of importance is the establishment of a reliable measure of both CSE and GCSE (Torkzadeh et al. 1996, Marakas et al. 1996). Nineteen of the studies reviewed used a self-developed measure of CSE or GCSE. IS research has been criticized in the past for its lack of care in the development and validation of its measures (Zmud and Boynton 1991, Straub 1989). While we concur with Compeau and Higgins (1995a) that validation is an ongoing process requiring assessment across a variety of studies in similar and dissimilar contexts, we also argue that for such validation to occur the measure must first focus on the construct of interest to the exclusion of other related constructs. If IS research is to pursue exploration of the complex relationships between CSE and other use and performance-related variables, we must first focus our attention on the development of reliable measures of the construct. Such measures must demonstrate not only the necessary levels of convergent and content validity but, more important, must also demonstrate evidence of strong divergent validity from other related constructs. We agree with Stone (1994) that given the increasing reliance on information technology in work settings, the relationship between CSE and organizational innovations intended to improve productivity and decision-making appears to be an important topic for future research.

In addition, we encourage future researchers to pursue studies intended to refine the psychometric properties of the construct, particularly with regard to complex tasks. What are the various estimation processes by which meaning is inferred from informational cues? How does the orchestration of CSE estimation actually occur?

We believe that the investigation of the relative sensitivities of the many antecedent and consequent factors of CSE to various training approaches should also be pursued. What are the boundary conditions on the effectiveness of various CSE enhancement approaches? Is there a ceiling effect with regard to CSE

enhancement? What individual differences are particularly salient in determining the types of individuals who may be affected by certain CSE manipulations or who may be affected by various confounds to CSE enhancement?

In closing, we believe the research efforts to date into the nature of computer self-efficacy each represent a positive step toward understanding the nature of the construct and its value to a wide variety of applied domains. The models of GCSE and CSE along with the guidelines contained herein are offered as yet another step toward this awareness. We encourage researchers to continue this stream of investigation and to increase their scrutiny of both the methods and measures employed with an eye toward refinement of the investigative process and, thus, the improvement of our ability to gain from our efforts.¹³

Appendix A

Initial Performance Characteristics

Martocchio (1992, 1994)
Martocchio and Dulebohn (1994)
Gist et al. (1989)
Mitchell et al. (1994)
Webster and Martocchio (1993)
Compeau and Higgins (1995b)
Martocchio and Webster (1992)
Murphy et al. (1989)
Russon et al. (1994)

Task Characteristics and Situational Support

Henry and Stone (1994)
Igbaria and Iivari (1995)
Russon et al. (1994)
Jorde-Bloom (1988)

Perceived Effort/Persistence

No studies found

Verbal Persuasion/Vicarious Experience/Feedback

Smith (1994)
Hill et al. (1985)
Busch (1995)
Henry and Stone (1995)
Compeau and Higgins (1995b)

Martocchio and Dulebohn (1994)
Martocchio and Webster (1992)
Gist et al. (1989)

Goal Setting, Anchoring, and Goal Commitment

Martocchio and Dulebohn (1994)
Age

Webster and Martocchio (1993)
Jorde-Bloom and Ford (1988)
Jorde-Bloom (1988)
Martocchio (1994)
Martocchio and Dulebohn (1994)
Kinzie et al. (1994)
Burkhardt and Brass (1990)
Murphy et al. (1989)

Time

Ertmer et al. (1994)
Marakas et al. (1996)

Direction-Following Behavior

Carlson and Grabowski (1992)

Professional Orientation

Jorde-Bloom and Ford (1988)
Jorde-Bloom (1988)

Prior Performance Characteristics/Attribution of Cause

Martocchio and Dulebohn (1994)
Martocchio (1994)
Compeau and Higgins (1995b)
Henry and Stone (1995)
Busch (1995)
Ogletree and Williams (1990)
Martocchio and Webster (1992)
Miura (1987)
Martocchio (1992)
Henry and Stone (1994)
Murphy et al. (1989)
Igbaria and Iivari (1995)
Jorde-Bloom (1988)
Hill (1987)

Webster and Martocchio (1993)
Mitchell et al. (1994)
Henderson et al. (1995)
Kinzie et al. (1994)
Delcourt and Kinzie (1993)

Computer Anxiety, Emotional Arousal, and Emotion-Focused Coping

Martocchio 1994 (1992)
Igbaria and Iivari (1995)
Henderson et al. (1995)
Henry and Stone 1994 (1995)
Martocchio and Webster (1992)
Harrison and Rainer (1992)
Delcourt (1994)

¹³The authors gratefully acknowledge the invaluable contributions of the associate editor, the anonymous reviewers, Bradley C. Wheeler, and Susan Winter in the revision and preparation of this paper for publication. Their suggestions and comments were both useful and insightful and, in every respect, focused on the common objective of bringing this manuscript to print.

Gender

Busch (1995)
 Russon et al. (1994)
 Igbaria and Iivari (1995)
 Ogletree and Williams (1990)
 Jorde-Bloom (1988)
 Mitchell et al. (1994)
 Carlson and Grabowski (1992)
 Delcourt and Kinzie (1993)
 Kinzie et al. (1994)
 Murphy et al. (1989)
 Miura (1987)
 Hill et al. (1985)
 Smith 1994
 Torkezadeh and Koufteros (1994)
 Martocchio and Dulebohn (1994)
 Martocchio and Webster (1992)
 Martocchio (1992)
 Webster and Martocchio (1993)
 Hill et al. (1987)
 Ertmer et al. (1994)
 Compeau and Higgins (1995b)
 Gist et al. (1989)
 Henderson et al. (1995)
 Jorde-Bloom and Ford (1988)

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Chris Higgins, Associate Editor. This paper has been received on April 26, 1996, and was with the authors 7 months for 2 revisions