2003

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This article originally appeared in the *Proceedings of the Ninth Americas Conference on Information Systems*. Tampa, Florida, 2003

12-31-2003

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Abstract

We report the results of a pilot study that compared the computer self-efficacy construct with metacognition. While self-efficacy is primarily affective and refers to one's beliefs about one's ability to perform a task, metacognition is primarily cognitive and refers to one's thoughts about one's ability to perform a task. Given their similarity, both have been used as surrogate measures of knowledge or skill. We developed an instrument to measure both constructs and applied the instrument to a set of MIS students taking an Analysis and Design course. Factor analysis produced a five-factor model, with metacognition factoring out as a unidimensional scale. Implications for further research are discussed.

Introduction

Self-efficacy is a belief in one's ability to produce a required level of attainment (Bandura, 1986, 1997), and is said to affect an individual's expressed interest in, selection, effort, and persistence in performing a task. As such, self-efficacy is often used to predict an individual's ability or desire to perform a task (Gist, 1987; Stajkovic & Luthans, 1998). Given the dominance of information technology within an organizational and educational context, this construct has been adapted as a potential measure of users' ability or desire to use information technology (Compeau & Higgins, 1995a; Gist et al. 1989; Hill et al. 1987). In particular, the computer self-efficacy (CSE) construct (Compeau & Higgins, 1995b) has been used as a predictor of an individual's outcome expectations of using computers, their emotional reaction to computers, and their actual computer use. Self-efficacy has also been used to assess the ability of students to learn (Piccoli et al. 2001; Ryan et al. 2000).

The problem is, the exact definition and role of self-efficacy – and hence, the exact definition and role of computer self-efficacy – has come under recent scrutiny. For instance, there is currently a debate in the psychological literature as to whether self-efficacy should be defined as a generalized individual trait or as a task-specific state (Chen et al. 2000, 2001). The confusion continues with studies that have used self-efficacy as a mediating rather than a moderating variable between conscientiousness and learning (Lee & Klein, 2002; Martocchio & Judge, 1997), while others have doubted the positive relationship between self-efficacy and performance, suggesting instead that over-confidence can lead to a negative relationship (Vancouver et al. 2002). The same problems of defining computer self-efficacy have arisen within the IS literature, with questions raised over the formulation and measurement of the construct (Marakas et al. 1998; Johnson & Marakas, 2000), the relationship between a general and task-specific computer self-efficacy (Agarwal et al. 2000), and the role of individual traits as antecedents of computer anxiety and self-efficacy (Thatcher & Perrewe, 2002).

This paper seeks to further clarify the definition and role of self-efficacy by comparing self-efficacy to a related construct called metacognition. Metacognition is literally thinking about thinking, or knowing about knowing, and is studied by cognitive and educational psychologists in terms of the way individuals monitor and control their thought processes (Nelson & Narens, 1996). The similarity between self-efficacy and metacognition is that, like self-efficacy, metacognitive self-assessments have been used as a surrogate measure of knowledge and skill, with the implication that an improvement in the accuracy of these judgments will lead to an improvement in learning or task performance (Kruger & Dunning, 1999). This similarity often results in measurement instruments that use very similar items. The main difference between self-efficacy and metacognition is that, while self-efficacy is usually defined as positively correlated to actual performance, metacognitive judgments are often at odds with objective measures of learning or task performance. This phenomenon is known as metacognitive miscalibration (MM). Several reasons for MM have been hypothesized, including cue familiarity (Metcalfe et al. 1993), and the above average effect (Alicke et al. 1995; Dunning et al. 1989). Put simply, familiarity results in over-confidence, while few people are willing to admit they are "below average."

The first part of the study is reported here, in which we pilot an instrument that includes both self-efficacy and metacognitive items. The aim is to develop an instrument that measures declarative and procedural knowledge of the two main analysis and design techniques, namely, DFDs and ERDs. In the following sections, we will outline the development of the instrument and highlight the differences in measuring metacognition rather than self-efficacy. We will then present the results of applying this instrument to a set of 90 MIS students taking the core course in IS Analysis and Design at a large South-Western US University. Using factor analysis we show the instrument produces a five-factor model, with the self-efficacy items loading on three factors, while the metacognitive items load separately as a unidimensional scale. This suggests that: 1. self-efficacy and metacognition are two distinct constructs, and; 2. metacognition shows better psychometric properties, factoring as one dimension. Neither, however, correlates well with actual performance, measured using test scores. Implications for further research and application are then discussed.

Instrument Development

According to social cognitive theory (Bandura, 1986, 1997), self-efficacy beliefs vary by 1. the level or magnitude of task difficulty; 2. the strength of confidence in successfully performing a particular level of task difficulty, and; 3. the generality of task magnitude and strength beliefs across tasks and situations. Given the non-task specific nature of the generality dimension, it is often ignored. As such, self-efficacy instruments are normally developed as a related set of items that increase or decrease in task difficulty, along with a "no/yes" scale, with the "yes" response further expanded to include a 10 or 100 point scale indicating the respondent's confidence in completing the task. Given the increasing task difficulty represented by the order of the items, the sum of the questions the respondent answered "yes" to represents magnitude, while the sum of the responses along the point scale represents strength (Compeau & Higgins, 1995a). An alternative form is to use 5 or 7 point Likert scale on task items without the leading "no/yes" to capture only the strength of self-efficacy (Torkzadeh, et al. 1999; Murphy, et al., 1989). In this case, we developed twenty items that assessed student's self-efficacy on declarative and procedural aspects of ERDs and DFDs (five items each) in decreasing order of task difficulty from 'with no help,' to 'with help from the instructor.' To be comprehensive and compatible to Bandura's conceptualization, we used a "no/yes" with 10 point confidence scale for each item to capture both magnitude and strength.

Since metacognition is thinking about thinking, the items are developed in terms of an individual's *thoughts* regarding ability and performance. Affect is minimized in metacognitive items; the word "think" is used while the terms "feel" and "believe" are avoided. Metacognition is studied using both prospective and retrospective items (future or past performance) for both discrete and aggregate performance (one, or multiple items). For instance, Kruger and Dunning (1999) used retrospective items for aggregate performance by asking participants to estimate their percentile ranking *after* completing *multi-item* tests of humor, logical reasoning, and English grammar. Maki et al. (1994) used prospective items for aggregate performance by asking participants to estimate on a 6-point Likert scale "how poorly" they *would perform* on a *multi-item test* of a particular passage of text. Sinkavich (1995) used retrospective items for discrete performance by asking students to assess the "correctness" of their exam answers on a 5-point Likert scale *following each* exam item. Smith (2002) used both prospective and retrospective items asking students to rate their aggregate performance with respect to that of their peers (far below to far above average) for a test to be taken shortly thereafter, and once again after the test is completed.

With no standard method for soliciting metacognitive judgments we elected to use exam grades. Unlike the scales used in most metacognition research, exam grades have the advantage of being familiar to students, matching the scale used to rate actual performance, and capturing the concepts of above and below average without additional items. Items were designed to ask the students to predict their exam performance with regard to declarative and procedural knowledge of ERDs and DFDs in terms of both a numeric grade (0 to 100) and a letter grade (A to F). The actual exam consisted of a variety of conceptual questions to measure declarative knowledge and one problem-solving question to measure procedural knowledge for each task domain (DFD and ERD). The conceptual questions comprised a set of 30 multiple-choice questions while the problem-solving question involved developing a DFD or ERD from a given problem statement. The metacognition items are therefore prospective metacognitive measures of aggregate performance for declarative knowledge of DFDs and ERDs (the multiple-choice questions), and discrete performance for procedural knowledge (the problem-solving question).

Table 1. Item Descriptions, Factor Loading, and Reliabilities

	Metacognition Items	**(α =.98) Factor 1**	**(α =.85) Factor 2**	**(α =.95) Factor 3**	**(α = .96) Factor 4**	**Factor 5**
M1	What score would you expect on an exam covering only **declarative knowledge** of **DFDs** if you took the test today? (1 – 100)		**0.886**			
M2	What score would you expect on an exam covering only **declarative knowledge** of **ERDs** if you took the test today? (1 – 100)		**.852**			
M3	What grade would you expect on an exam covering only **declarative knowledge** of **DFDs** if you took the test today? (A – F)		**.700**			.487
M4	What grade would you expect on an exam covering only **declarative knowledge** of **ERDs** if you took the test today? (A – F)		**.700**	.452		
M5	What score would you expect on an exam covering only **procedural knowledge** of **DFDs** if you took the test today? (1 – 100)		**.882**			
M6	What score would you expect on an exam covering only **procedural knowledge** of **DFDs** if you took the test today? (1 – 100)		**.864**			
M7	What grade would you expect on an exam covering only **procedural knowledge** of **DFDs** if you took the test today? (A – F)		**.756**			.479
M8	What grade would you expect on an exam covering only **procedural knowledge** of **DFDs** if you took the test today? (A – F)		**.721**	.407		
Self-efficacy Items						
I could explain **DFD** definitions and concepts …(SE1M Magnitude)					**.841**	
S1	… with absolutely no help			**.678**		
S2	… with reference to my class notes	**.716**		.506		
S3	… with reference to my notes & textbook	**.803**				
S4	… with some help from a classmate	**.794**				
S5	… with some help from the instructor	**.841**				
I could* explain **ERD** definitions and concepts …(SE2M Magnitude)					**.794**	
S6	… with absolutely no help			**.760**		
S7	… with reference to my class notes	**.695**		.610		
S8	… with reference to my notes & textbook	**.788**		.445		
S9	… with some help from a classmate	**.796**				
S10	… with some help from the instructor	**.830**				
I could create a **DFD** from a problem description …(SE3M Magnitude)					**.855**	
S11	… with absolutely no help			**.556**		.475
S12	… with reference to my class notes	**.683**				.485
S13	… with reference to my notes & textbook	**.799**				
S14	… with some help from a classmate	**.770**				
S15	… with some help from the instructor	**.801**				
I could create an **ERD** from a problem description …(SE4M Magnitude)					**.891**	
S16	… with absolutely no help			**.649**	.451	
S17	… with reference to my class notes	**.709**		.487		
S18	… with reference to my notes & textbook	**.784**				
S19	… with some help from a classmate	**.764**				
S20	… with some help from the instructor	**.797**				

Analysis of Results

The instrument was administered to the students in class a few days before the first exam. In total, 90 usable responses were collected. To determine the number of factors in the instrument, exploratory factor analysis using principal component as the extraction method with varimax rotation was used. Table 1 presents the item descriptions, factor loadings, and reliabilities of the factors. The analysis resulted in five factors that clearly separate the metacognition items (Factor 2) from the self-efficacy items. However, the different aspects of learning defined in terms of declarative and procedural knowledge of ERDs and DFDs did not differentiate and loaded as one nebulous factor (Factor 1). The first questions (performing the task "with absolutely no help") and the magnitude of self-efficacy loaded into separate factors (Factors 3 and 4, respectively). This suggests that, as far as learning DFDs and ERDs are concerned, declarative and procedural knowledge is related, although respondents determined that it takes a different kind of strength or confidence to perform a task in this area with no help at all, while the magnitude and strength definitions of self-efficacy are different constructs. The last factor consists of items that have high loadings in other factors and therefore is difficult to interpret and could be the result of the small sample size used in the analysis. More data is needed to verify the significance of this last factor. The five factors explained 85.7% of the variance and 80% without the last factor. The reliabilities of the four factors are very high (from 0.85 to 0.98).

To examine predictive validity of the scales, correlation between metacognition scores, self-efficacy scores, and the exam scores were tested. In every case, averages of all items in each factor were used as the scale scores. Declarative knowledge was measured using the number of correctly answered multiple-choice questions, while procedural knowledge was measured using grades received on a modeling question. Since the factors did not reflect a declarative versus procedural distinction, scores for all four parts were standardized and averaged to generate an exam score for testing. As expected, metacognition scores are not correlated with the student's exam scores due to the existence of miscalibration. However, we also did not find significant correlations between the three self-efficacy measures and the exam scores. On the other hand, all self-efficacy scores are highly and significantly correlated with the metacognition scores (ranging from .350 to .730, all significant at the 1% level). Therefore, while factor analysis suggests that self-efficacy and metacognition are distinct constructs the correlation analysis also suggests they are related measures, but neither is related to actual performance. Clearly, people do not always have a good understanding of their own performance. This is the result predicted by metacognitive miscalibration.

Conclusions

We compared and contrasted self-efficacy and metacognition as an indicator of the performance of students taking an IS Analysis and Design course. We showed that there is a similarity between the items used to measure self-efficacy and those used for metacognition. The results of the pilot study show, as expected, that the item reliability of both sets of items is excellent, with Cronbach Alpha's above 0.85 for each set of items. However, using factor analysis we also found that the two constructs factor separately, with metacognition showing better psychometric properties by factoring as a unidimensional scale. The problem, however, is that neither the self-efficacy nor the metacognitive items correlated with actual performance. While the lack of correlation with metacognition is expected, the lack of correlation with self-efficacy is not. Further research is needed to clarify these results. We intend to determine the value of the constructs defined here in terms of their ability to predict learning or task performance, whether they act as moderating or mediating variables, and whether they are measures of individual traits stable over time, or task-specific states that vary from situation to situation. In particular, we are in the process of investigating the way in which self-efficacy and metacognition varies over time, with the expectation that early self-efficacy and metacognition scores need to be recalibrated by feedback before they can be effective predictors of actual performance. The score from a previous test would count as feedback. We also intend to investigate the role of antecedent and post-performance constructs, with the literature suggesting that personal innovativeness with IT, computer anxiety, and outcome expectations have a significant relationship to self-efficacy, and thus, perhaps also metacognition. Such an integrated model would have important implications for both educational researchers and industry in terms of understanding how to teach or train more effectively.

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