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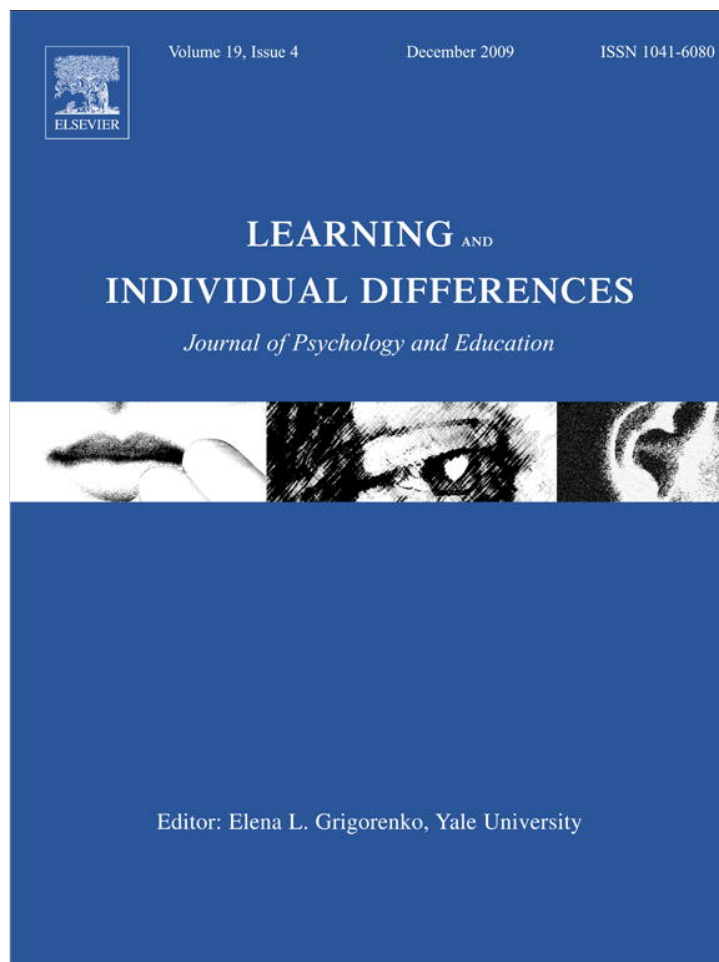
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Learning and Individual Differences

journal homepage: www.elsevier.com/locate/lindif

Developing experience-based (tacit) knowledge through reflection

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ARTICLE INFO

Article history:

Received 23 August 2007

Received in revised form 26 June 2009

Accepted 5 July 2009

Keywords:

Experience-based learning

Workplace learning

Reflection

Tacit knowledge

ABSTRACT

This investigation examined the effectiveness of reflection methods derived from Sternberg's theory of practical intelligence [Sternberg, R.J., and Hedlund, J. (2002). Practical intelligence, g, and work psychology. *Human Performance* 15(1/2), 143–160.; Sternberg, R.J., Forsythe, G.B., Hedlund, J., Horvath, H.A., Wagner, R.K., Williams, W.M., et al. (2000). *Practical intelligence in everyday life*. New York: Cambridge University Press. 2000] on the acquisition of experience-based, tacit knowledge. Two related experimental studies were conducted to test the effect of brief tacit-knowledge reflection training on practical problem solving. Reflection methods were developed based on Sternberg's conceptualized condition–action structure of tacit knowledge. In the first study, 101 U.S. Army officers participated in a reflection intervention or practice control. Results showed an effect of reflection condition on post-test tacit-knowledge scores ($F[3, 91] = 3.74, p = .01, 2 = .03$). In the second study, 235 college students participated in a reflection intervention or an academic-type reflection control. Results showed that the reflection condition approached significance on post-test scores ($F[1, 233] = 3.47, p = .06, p = .06, 2 = .01$). The investigation suggests this line of inquiry warrants continued study.

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1. Introduction

To succeed in organizational environments characterized by continuous change, professionals must enhance their capacity to learn from experience and adapt their modes of practice accordingly. Experience-based knowledge is context-dependent and typically develops over time through an iterative learning process of perception, action, and feedback. In the current organizational environment, opportunities to engage in this learning process may be sharply reduced or even forestalled. Developing methods to enhance the acquisition of experience-based knowledge have never been more relevant to professional education and development. Is it possible to develop training methods that facilitate the acquisition of experience-based knowledge? This article investigates this question utilizing methods based on Sternberg's theory of practical intelligence (Cianciolo, Grigorenko, Jarvin, Gil, Drebot & Sternberg, 2006; Hedlund & Sternberg, 2000; Sternberg, Forsythe, Hedlund, Horvath, Wagner, Williams et al., 2000; Sternberg & Hedlund, 2002).

Reflection on experience has been advocated as a way to facilitate experience-based learning primarily in organizational/management and education literatures (Argyris, 1991, 1994, 1999; Kolb, 1984; Marsick, 1988, 1990; Marsick & Watkins, 1997; Raelin, 1997; Schön, 1983, 1987; Seibert & Daudelin, 1999). It is defined here as a process of guided critical thinking that directs attention selectively to various

aspects of experience, making knowledge typically acquired without conscious awareness explicit and available for examination and modification. Although the role of reflection has long been established as an important component of experience-based learning, it remains unclear what the benefits and limitations are of different types of reflection and to what extent they appreciably enhance professional performance. The vast majority of empirical studies of workplace learning between 1990 and 2002 have been conducted at an organizational level of analysis (Bapuji & Crossan, 2004). More individual-level empirical work is needed to inform the design of reflection methods that are associated with particular performance outcomes and increase our understanding of underlying psychological processes (Seibert & Daudelin, 1999).

A distinction has been made between explicit versus implicit, or tacit dimensions of knowledge acquired from experience (Neisser, 1976; Polanyi, 1966; Schön, 1983; Sternberg & Horvath, 1999a,b; Wagner & Sternberg, 1985). Tacit knowledge, which is deeply rooted in action and context, can be acquired without awareness and is typically not articulated or communicated. In contrast, explicit knowledge is that which is articulated, codified, and transmittable through formal, systematic language. Tacit knowledge has been recognized as both an outcome of experience-based learning and as a basis for continuous learning (Nonaka, 1994; Raelin, 1997; Sternberg, 1996, 1997; Sternberg & Horvath, 1999a,b).

Some scholars believe that experienced-based learning can be developed or reconstructed by making tacit knowledge explicit (Argyris, 1994; Raelin, 1997; Schön, 1983; Sternberg, 1998b). Toward

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this end, reflection methods have been developed that fundamentally vary in terms of how tacit knowledge is conceptualized. In the management literature, these methods have been criticized for being largely non-theoretical, prescriptive, and lacking in sufficient empirical support (Seibert & Daudelin, 1999). Theoretical and empirical contributions from cognitive psychology have the potential to contribute to this state of affairs by conceptualizing how tacit knowledge is acquired and specifying underlying cognitive processes that can be applied to the design of reflection methods.

This study investigated the effectiveness of reflection methods derived from the practical intelligence subtheory (Sternberg & Hedlund, 2002; Sternberg, Forsythe, Hedlund, Horvath, Wagner, Williams et al., 2000) of Sternberg's theory of successful intelligence (1983, 1985, 1988, 1996, 2005). According to the theory, there are individual differences in the ability to learn from experience (practical intelligence) and acquire tacit knowledge, an important component of it. Moreover, the theory suggests that the ability to learn from experience can be developed. Sternberg's theory provides a cognitive account of how experience-based tacit knowledge is acquired specifying cognitive processes that can be made explicit to facilitate the acquisition of tacit knowledge. When these processes are applied to the design of reflection methodology, major conceptual approaches in the organizational/management and education literatures are neatly encompassed. Reflection methods based on Sternberg's theory can be applied to individual or group-level reflection training. An individual reflection format was selected for this investigation in response to the recent trend toward the use of individual-level, web-based education in management (Arbaugh & Duray, 2002) and other professions (Kanuka & Nocente, 2003). In addition, an individual reflection format makes it possible to test the effect of cognitive training independent of the influence of social factors inherent in group reflection formats.

2. Background

2.1. Workplace learning

Professional-learning and development literatures emphasize workplace learning as primarily experience-based and social in nature (e.g., Bapuji & Crossan, 2004; Cianciolo, Antonakis, & Sternberg, 2004; Marsick & Watkins, 1997; Raelin, 1997, 2001). As such, strategies have been developed to engage the learner in a process of reflection, articulation, and examination of experience in the hopes that it will facilitate learning. Some examples include action learning, mentoring, coaching, and communities of practice. Raelin's (1997) model of work-based learning incorporates tacit forms of knowledge and experience-based modes of learning. Raelin advocates public reflection to enhance tacit knowledge at multiple levels of experience – individual, team, organization and society (Raelin, 2001). Despite the rather enthusiastic endorsement of reflection as a means to develop workplace learning, little seems to be known about the types of reflection that may lead to enhanced learning.

Reviews of the state of organizational-learning research note a lack of systematic empirical research (Bapuji & Crossan, 2004). Given the rapid rate of change in organizational environments and professional practice, studies that specify the types of reflection that are most effective in facilitating experience-based learning would seem to have practical utility in higher education and professional-development programs.

2.2. Experiential learning

Inquiry into the nature of and processes involved in learning from experience and recognition of the important role of tacit knowledge has been pursued by scholars from a range of disciplines including education (Dewey, 1910; Kolb, 1984), philosophy (Polanyi, 1966),

psychology (Lewin, 1951; Reber, 1989; Sternberg, Forsythe, Hedlund, Horvath, Wagner, Williams et al., 2000), and organization/management (Argyris, 1976; Nonaka, 1994; Schön, 1983). Several treatments suggest there may be ways to make tacit knowledge explicit and, thus, available for development.

Polanyi (1966) recognized the importance of the ability to implicitly acquire knowledge from experience through a connection between a pattern of stimuli or events and an experience. He noted that a critical factor contributing to tacit, rather than explicit, acquisition of knowledge is the direction of attention away from the particular stimuli or events that give rise to an experience and toward the internal sensations stimulated by them. This implies that directing attention toward particular stimuli or events that give rise to an experience may function to make tacit knowledge explicit.

Schön (1983) emphasized the role of action in shaping the content of tacit knowledge. He observed that when actions lead to unexpected action outcomes, reflection on assumptions that gave rise to the action is prompted, which augments tacit knowledge. He examined two types of thought processes utilized when customary responses to situations prove ineffective, reflection-in-action, which occurs on the spot, and reflection-on-action, which occurs retrospectively. Schön's work implies directing attention toward the link between assumptions that lead to action and action outcomes may function to make tacit knowledge available for development.

Neisser (1976) first made the distinction between practical intelligence, as it pertains to learning from experience, and intelligence associated with academic success. In a more comprehensive treatment, Sternberg (1985, 1996) distinguished practical from analytic and creative abilities in terms of the ability to solve practical problems in real-world contexts. According to the theory, the practical ability to learn from experience involves cognitive processes through which tacit knowledge is applied to and modified by new experiences. According to Sternberg, tacit knowledge is a complex set of condition-action mappings through which appropriate action is selected and executed, given specific environmental conditions. In cognitive terms, it is procedural rather than declarative in orientation, such that it contains information regarding appropriate responses under particular environmental conditions (knowing how) rather than knowledge about the particular situation (knowing that). It tends to be acquired through a process that is closely linked to the accomplishment of personally valued goals with little explicit support from external sources. Tacit knowledge is difficult but not impossible to articulate verbally, and is demonstrated by the capacity to solve domain-specific problems of a practical nature.

Sternberg's conceptualization of tacit knowledge as condition-action mapping incorporates Polanyi's emphasis on patterns of stimuli or conditions that give rise to experience (condition aspect) and Schön's emphasis on action and action outcomes of experience (action aspect). It provides a framework for understanding in cognitive terms how Polanyi and Schön's approaches can be linked in the design of reflection methods that have the potential to facilitate the development of tacit knowledge.

2.3. Reflection methodology

As indicated previously, many scholars consider reflection to be an essential ingredient of experiential learning. Various methods have been developed that vary in terms of the extent to which social factors are emphasized. Reflection methods that highlight social factors utilize formats that involve peers and experts (Raelin, 2001). The basic principle underlying these approaches is that learning requires social interaction, including feedback and collaboration on shared activities in an authentic context. Examples of such methods include action learning, in which peers engage in reflection as they work together on real problems in real contexts (Revans, 1982); and action science, which also involves reflection among peers with expert guidance for

purposes of uncovering, examining, and modifying deep assumptions that inhibit organizational learning (Argyris, 1994). Communities of practice are another example where groups of people with varying levels of expertise informally come together to exchange knowledge and experience in a shared domain of interest (Gherardi, Nicolini, & Odella, 1998; Lave & Wenger, 1991; Lesser & Storck, 2001; Nonaka & Takeuchi, 1995; Wenger, 2000).

Individual approaches to reflection make tacit knowledge explicit and available by stimulating introspective examination through a questioning process that directs attention to various aspects of experience. For example, critical mindfulness practice, which involves individual reflection on all aspects of professional practice, has been explored by Epstein (1999) in medical practice. Other examples of individual methodologies include the recording of experiences (e.g., journal writing), written response to semi-structured questions, and use of mentors or coaches to structure questions and provide limited feedback.

It seems plausible that reflection methods may be differentially effective, depending on the extent to which social factors are emphasized. However, there appears to be limited research along this line of inquiry. In one study, Daudelin (Daudelin, 1996; Seibert & Daudelin, 1999) investigated the relative effect of reflection method (individual reflection, peer-group discussion, and tutor guidance) on quantity of self-reported learning acquired from developmental experiences in managers of business organizations. Reflection questions were derived from principles reported in the education literature pertaining to specificity (e.g., related to particular events, people, or actions), types (e.g., probing assumptions), and sequence of questions. Findings suggest that the individual and tutor-guided methods were superior to the peer-group format under this particular reflection methodology. Analysis of the peer-group session suggests various social factors may have impeded learning. In this study, peers tended to: (1) search for similarities among experiences, placing less emphasis on learning that was unique to themselves; (2) discourage detailed probing that may have elicited more learning; and (3) avoid instructions about taking notes or use of reflection questions in their discussion. These results suggest that social factors may mediate the effectiveness of any particular training methodology. For this reason, it makes sense to evaluate reflection methodology independent of the influence of social factors.

3. Conceptual model

Sternberg asserts that intelligence is inherently malleable and can be conceptualized as a developing form of expertise (Sternberg, 1996, 1998a, 1999). His theory of intelligence as it applies to practical abilities suggests cognitive processes through which experience-based (tacit) knowledge can be developed that focus on the condition as well as action aspects of experience (Sternberg et al., 2000). The theory suggests that experience-based learning is ultimately shaped by cognitive processes associated with the acquisition of tacit knowledge and practical problem solving applied to new experience.

The theory posits three cognitive processes that underlie the acquisition of tacit knowledge: selective encoding, selective combination, and selective comparison of information, all of which have bearing on an individual's capacity to learn from experience. These processes interact to reduce and organize the vast amount of information in any given situation. Selective encoding involves attending to information that is relevant to personally valued goals. Through selective combination, this encoded information is integrated to form a meaningful pattern. Through selective comparison, this pattern of information is compared to previously acquired tacit knowledge.

According to the theory, in the face of new experience, previously acquired tacit knowledge informs or shapes practical problem solving. The cognitive functions that make up practical problem solving, called "metacomponents," include problem identification, resource alloca-

tion, representation and organization of information, formulation of solutions, monitoring of solutions, and evaluation of solution outcomes. Generally speaking, when tacit knowledge has been effectively acquired from prior experience and appropriately applied to new situations, it enhances practical problem solving. However, when tacit knowledge has not been effectively acquired from prior experience, or is no longer applicable to a new experience, it may hinder practical problem solving. In this circumstance, unexpected action outcomes may lead to modification or further refinement of knowledge structures through the effective application of the metacomponents of practical problem solving.

In general, two types of situational-judgment testing methods, surveys and case studies, have been developed to assess practical problem solving and domain-specific tacit knowledge (Cianciolo, Matthew, Wagner, & Sternberg, 2005). Both are derived from subject matter experts and represent realistic and practical problems that might be encountered in a particular domain. As such, they can be considered low-fidelity simulations of domain-specific situations (Motowildo, Dunnette, & Carter, 1990).

Occupation-specific tacit-knowledge surveys have been developed and tested in areas including military leadership, management, sales, and college life (Sternberg et al., 2000; Sternberg & Hedlund, 2002). Tacit-knowledge case studies have been developed to assess practical problem solving in business school admissions (Hedlund, Wilt, Mebel, Ashford & Sternberg, 2006).

3.1. Reflection interventions

Consistent with Sternberg's theory, reflection training interventions were developed for this investigation to make tacit knowledge explicit, unpack its condition–action structure, and make it available for reflection. Training interventions in the form of guided critical thinking exercises applied conceptualized knowledge-acquisition processes (selective encoding, selective combination, and selective comparison) and metacomponents of problem solving to tacit-knowledge surveys and case studies. Three training interventions were developed, each of which emphasized different aspects of the theorized condition–action structure of tacit knowledge. The *condition-focused method* facilitated reflection on problem identification and goal formulation. It included questions that uncovered factors considered in problem identification, and probed underlying assumptions associated with problem definition and solution goals. The *action-focused method* facilitated reflection on the link between action and action outcomes. It included a guided comparison of the subject's own response rating to alternative response ratings with questions that probed alternative assumptions about goals and action outcomes. The *condition and action-focused method* facilitated reflection on elements of both the condition and action. Reflection questions prompted examination of an alternative response in regard to problem identification, goals, actions, and anticipated action outcomes.

Tacit-knowledge training interventions were manipulated in experimental conditions. In the first study (military sample), a no-training control condition was designed, in which subjects considered similar domain-relevant problem situations, without exposure to the TK training intervention. In the second study (college sample), an analytic reflection control was developed, in which materials that described issues in college life were presented followed by analytic questions much like those typically found in academic coursework (e.g., react to issues presented and identify the pros and cons of a particular position). A sample condition and action-focused training intervention utilized in the second study is displayed in Appendix A.

3.2. Hypotheses and predictions

Based on the foregoing conceptual discussion, we predicted that tacit-knowledge reflection training would improve practical problem

solving more than no training. Moreover, it was expected that a tacit-knowledge reflection training program that focused on both condition and action aspects of tacit knowledge would improve practical problem solving to a greater extent than training interventions that targeted only one aspect of the model. Finally, we predicted that a tacit-knowledge reflection training program that contained condition and action aspects of the problem would improve practical problem solving more than an academic-type guided reflection. These predictions are expressed in the following hypotheses:

H1. Tacit-knowledge reflection training that focuses on one or both condition and action aspects of a practical problem will improve practical problem solving more than a no-training control.

H2. Tacit-knowledge reflection training that focuses on both condition and action aspects of a practical problem will improve practical problem solving more than training that focuses on either aspect separately.

H3. Tacit-knowledge reflection training that focuses on both condition and action aspects of a practical problem will improve practical problem solving more than analytic (academic-type) reflection.

To investigate the effect of these theory-based reflection interventions, two related experimental studies were conducted that built on previous research on tacit knowledge in the domains of military leadership and college life utilizing domain-specific tacit-knowledge measures that had been previously developed. The first study was designed to examine Hypotheses 1 and 2 for the purposes of potential education and training applications. In the first study, the differential effects of TK reflection training that focused on condition, action, or condition–action aspects of practical problem solving, and a no-training control, were administered to a sample of military leaders. The second study was designed to examine Hypothesis 3 to distinguish the effects of TK reflection training from analytic reflection characteristic in academic training. A tacit-knowledge reflection training program that focused on combined condition and action aspects of practical problem solving was compared to an analytic reflection control in a sample of college students. College students were utilized primarily because Army Officers were not available for additional testing. However, an advantage of the college student sample was the opportunity to assess generalizability of TK training across settings.

4. Study 1: developing Tacit Knowledge In Military Leadership

4.1. Methods

4.1.1. Subjects

One hundred one (101) Army officers from various branches (e.g., infantry, field artillery, air defense, etc.) at three Army bases in the Northeast and Midwest participated in the study. Twenty-nine (28.7%) were lieutenants (LTs), 30 (29.7%) were captains (CPTs), 22 (21.8%) were majors (MAJs), and 20 (19.8%) were lieutenant colonels (LTCs). In term of years of military experience, LTs had an average of 4 years ($SD = 3.7$), CPTs, an average of 7.5 years ($SD = 3.8$), MAJs, an average of 15.5 years ($SD = 2.7$), and LTCs an average of 19 years ($SD = 1.7$). Ninety-seven (96%) were men and 4 (4%) were women. Participants ranged in age between 22 and 50 years with a mean age of 32.9 and a standard deviation of 6.8 years.

Table 1 presents the distribution of subject by military rank in each of the three experimental and control conditions. Due to limitations associated with sample access, the distribution of subjects by military rank was variable. As can be seen by the marginal frequencies in the table, the distribution across conditions ranged from 20 to 28. In experimental conditions, the distribution of subjects by rank ranged from 16 to 28.

Table 1
Officer rank across conditions in analyzed sample.

Rank	Control	Experimental condition			Total
		Condition	Action	Combined	
LT		10	8	9	27
CPT	14	6		8	28
MAJ	5	1	4	11	21
LTC	5	11	4	0	20
Total	24	28	16	28	96

Note. LT = lieutenant, CPT = captain, MAJ = major, and LTC = lieutenant colonel.

4.1.2. Procedure

Army officers were asked by their superiors to attend a scheduled session to recruit participants. Attendees were told the purpose of the study was to test methods to enhance experience-based learning in military leadership. Officers who chose to participate (98%) remained for a single, three-hour session administered by two experimenters in a classroom setting. Depending on the particular session attended, participating officers received one of three self-paced experimental intervention packets or a no-training control packet. Administrations of experimental and control packets were alternated by session to obtain a relatively nearly equal number of participants across ranks in each of the experimental and control groups.

First, a demographic survey and a self-paced tacit-knowledge pre-test were administered followed by a short break (10–15 min). After the break, participants in experimental conditions completed one of three self-paced reflection interventions (*condition-focused*, *action-focused*, or *condition and action-focused*), in which they first read material that described the cognitive processes that underlie practical problem solving in lay terms. Then, they responded to theory-based questions designed to stimulate reflection on tacit-knowledge surveys and case studies considered in the pre-test assessment. In the control condition, another tacit-knowledge measure was administered. The experimental and control interventions took 30–40 min to complete. After another short break, participants completed a self-paced tacit-knowledge post-test and Satisfaction with Intervention survey (experimental conditions only). Lastly, experimenters administered cognitive-ability tests to be used as covariates.

4.1.3. Measures

Tacit Knowledge in Military Leadership (TKML; Horvath, Hedlund, Snook, Forsythe, & Sternberg, 1998; Hedlund, Williams, Horvath, Forsythe et al., 1999).

This survey features a series of brief problem situations (“vignettes”) that may be encountered in Army leadership. Each vignette presents a problem situation and a set of solution alternatives that participants are asked to rate for quality on a variable-point Likert scale (e.g., 1 = “extremely bad”; 9 = “extremely good”). There are three versions of the survey (platoon, company, and battalion levels), each of which contains 18 items. Eight vignettes were selected from each version to create pre-test and post-test blocks of four different vignettes. The criterion for vignette selection was low response variance in expert sample. Vignette blocks were counterbalanced to equate pre- and post-tests. Participants received only rank-appropriate surveys to control for difficulty associated with rank differences. Scores are calculated by taking the Euclidean distance from the expert mean on each item and squared. Internal-consistency estimates of complete versions of the TKML range from .66 to .76. Evidence of construct and criterion-related validity is reported by Hedlund et al. (1999).

Military case studies (Matthew, Cianciolo, & Sternberg, 2005). The TK case study consists of a detailed description of the particulars of a problem situation as it unfolds over time, followed by a set of open-ended questions designed to assess knowledge-acquisition components and practical problem solving skills (Cianciolo, Matthew, Wagner, &

Sternberg, 2005), an approach that has been used previously in tacit-knowledge research (Hedlund, Wilt, Mebel, Ashford, & Sternberg, 2006).

Two platoon-level military leadership case studies (PS2 and PS3) were created from interview data and qualitative analysis of archival tacit-knowledge data (Hedlund et al., 1999) and subsequently reviewed by subject matter experts (two senior Army officers). Six open-ended questions designed to measure practical problem solving and tacit knowledge were included in the case studies. A sample question is “What problems need to be addressed in this situation?” Participants responded to questions by speaking into digital voice recorders. Case studies were scored on comparisons with relevant tacit-knowledge content previously obtained through research and assess for the quality of metacomponential processing including: problem identification, selected course of action, and, anticipated action outcomes and obstacles. Three trained research assistants scored transcribed responses. Inter-rater reliabilities, estimated by an intraclass correlation (two-way mixed effects), were .85 for PS2 and .84 for PS3.

Cattell culture fair test of g (Cattell & Cattell, 1963). This test is designed to assess intelligence equivalently across cultural groups using non-verbal stimuli (the culture-fair status of the test is, of course, debatable—Sternberg (1997)). The full test contains three scales, each of which is made up of multiple subtests. Two timed subtests that require participants to select patterns from among figures from Scale 2 were administered to measure fluid cognitive ability. The first subtest has 10 items and the second, 14 items. Full-scale reliabilities have been reported ranging from .85 to .91.

Mill Hill Vocabulary Scale (Raven, Raven, & Court, 1985). This untimed, 66-item test of vocabulary is designed to measure crystallized cognitive ability. Participants are presented with a word and must select from among four options the closest synonym to the word presented. A short form of the test containing 33 items was administered in this study. Full test split-half reliability of .90 and test-retest reliabilities of .87 to .95 have been reported.

Satisfaction with Intervention covariate.

This survey was developed for this study to control for the effect of possible differences in satisfaction with the interventions on post-test performance. Participants are asked to rate the degree to which they agree with a series of six statements about the experimental intervention on a three-point scale (1 = disagree, 2 = neither agree nor disagree, and 3 = agree). A sample item is “I learned something from the intervention.” Internal-consistency reliability for this administration was $\alpha = .84$.

4.2. Results

4.2.1. Initial analyses

Four participants accidentally received inappropriate versions of the tacit-knowledge inventory and were removed from the dataset. One significant outlier was also removed. Seven participants did not complete case study measures and 10 failed to complete all the cognitive-ability tests.

Internal-consistency reliabilities are presented in Table 2. All but one, the PS2, fell within the suggested range of .5 to .8 for Situational Judgment Tests (Legree, 1995). Split-half reliabilities of cognitive-ability tests were acceptable.

Descriptive statistics and intercorrelations of covariates as well as independent and dependent variable measures are displayed in Table 3. The TKML and PS2 did not correlate as expected possibly due to low reliabilities; the pre-test correlation was $r(42) = .25$; and the post-test correlation, $r(42) = .07$. There were no significant mean differences between experimental and control groups on satisfaction and cognitive-ability covariate measures. There was no effect of version on TKML pre- and post-test scores.

Case study scores were not collapsed into pre- and post-test scores but rather were analyzed separately because statistical analyses sug-

Table 2
Reliability of Study 1 measures.

Measure	N	Reliability estimate
TKML: platoon	8	.64
TKML: company ^a	7	.58
TKML: battalion	8	.67
PS2 CS	5	.44
PS3 CS	5	.51
Mill Hill	33	.91
Cattell	24	.86

Note. Reliability estimates are Cronbach alpha values except for the Cattell, which is split-half.

TKML = Tacit Knowledge in Military Leadership Survey.

PS2 CS = Platoon Scenario 2 Case Study.

PS3 CS = Platoon Scenario 3 Case Study.

^a One item with low intercorrelation omitted.

gested they were not equivalent. There was evidence of a significant effect of interaction of test version on case study pre- and post-test scores ($F[1, 87] = 24.57, p = .00, \eta^2 = .22$). Participants who received the PS2 in pre-test improved on the PS3 post-test; those who received PS3 in pre-test declined slightly in performance on the PS2 post-test.

4.2.2. Hypothesis tests

4.2.2.1. Tacit-knowledge surveys. To test the differential effects of experimental reflection methods and no-reflection methods (control group) on tacit-knowledge survey (TKML) performance, a GLM univariate analysis of variance was conducted with the TKML post-test as the dependent variable, experimental condition as the independent variable, tacit-knowledge survey (TKML) pre-test as a covariate, and simple contrasts between experimental and control groups. Because random assignment was not implemented and sample size was limited, this method made it possible to control for individual differences with minimal loss of degrees of freedom in the test. Results show a significant effect of condition, $F(3, 91) = 3.74, p = .01, \eta^2 = .03$. Pairwise comparisons show that only the combined condition and action reflection method was significantly different from the control condition, mean difference = $-.70, p = .03$ based on estimated marginal means. Table 4 displays full results. Comparisons of the distance from the expert mean squared scores show that

Table 3
Descriptive statistics and intercorrelations among tacit-knowledge and cognitive-ability measures.

	N	Mean	SD	1	2	3	4	5	6	7	8
1. TKML pre-test	96	3.24	1.32	1							
2. TKML post-test	96	2.77	1.29	.36**	1						
3. PS2 CS pre-test	42	5.42	1.48	.25	.27	1					
4. PS2 CS post-test	48	5.39	1.32	.07	.07	–	1				
5. PS3 CS pre-test	48	5.39	1.32	.22	.28	–	.30*	1			
6. PS3 CS post-test	42	6.05	1.51	.12	.13	.40**	–	–	1		
7. Cattell	86	12.91	3.17	.25	.29	.22	.03	.16	.20	1	
8. Mill Hill	86	19.03	3.41	.07	.30	.38*	.16	.09	.06	.29**	1

Note. TKML (distance scores) correlations were reversed for ease of interpretation. All correlations among case study pre- and post-tests were not obtainable. Half the sample received Version A.

(PS2 pre-test, PS3 post-test) and the other half received Version B (PS3 pre-test, PS2 post-test).

TKML = Tacit Knowledge in Military Leadership Survey.

PS2 CS = Platoon Scenario 2 Case Study.

PS3 CS = Platoon Scenario 3 Case Study.

** Correlation significant at the 0.01 level (two-tailed).

* Correlation significant at the 0.05 level (two-tailed).

Table 4
Results of univariate analysis of variance with TKML as dependent variable with contrasts.

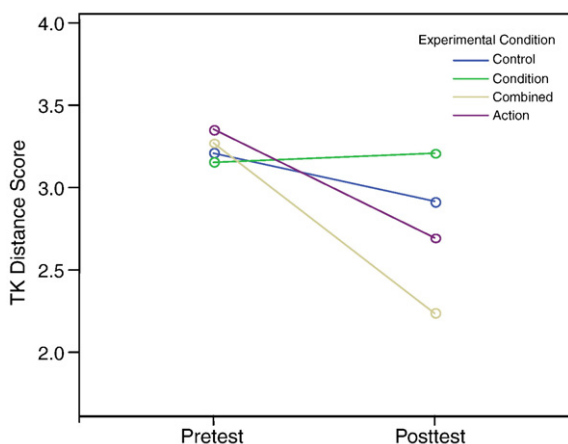
Source	df	F	Sig.
TKML pre-test	1	15.98	.00
Experimental condition	3	3.74	.01
Error	91		
Note. $R^2 = .22$			
No-training comparison	Mean difference	SE	Sig.
Condition	−0.32	0.32	.33
Action	0.27	0.38	.47
Combined	−0.70	0.32	.03

Note. TKML = Tacit Knowledge in Military Leadership Survey.

participants in the combined condition ($M = 2.56, SE = .24$) were less distant from the experts than were those in the action-focused experimental group ($M = 2.64, SE = .32$), and in the condition-focused experimental group ($M = 3.21, SE = .24$). Fig. 1 displays the tacit-knowledge (TK) marginal means of distance from the expert mean squared scores in pre- (1) and post-test (2) for all experimental conditions.

These results provide preliminary support for Hypotheses 1 and 2. Practical problem solving as measured by tacit-knowledge survey scores was significantly higher in the reflection conditions as compared with the control condition; the combined reflection intervention resulted in statistically significant improvement in post-test survey scores. The condition-focused and action-focused interventions did not.

4.2.2.2. Tacit-knowledge case studies. As discussed previously, pre- and post-test case study scores were not compared because the PS2 and the PS3 were not psychometrically equivalent. For exploratory purposes, the differential effects of experimental reflection methods and no reflection (control) were analyzed on the PS2 data because there were an adequate number of participants in each condition. The TKML pre-test score was used in place of a case study pre-test score as a conceptually relevant proxy. A GLM univariate analysis of variance was conducted with the PS2 case study post-test as the dependent variable, experimental condition as the independent variable, and tacit-knowledge survey (TKML) pre-test and Mill Hill as covariates with simple contrasts between the experimental and control groups. The Mill Hill covariate was included to provide an additional control for individual differences associated with verbal ability, given the open-response format of the case study measure.



Note. TKML = Tacit Knowledge in Military Leadership Survey.
TK = Tacit Knowledge

Fig. 1. TKML mean score distance from expert means by experimental condition. Note. TKML = Tacit Knowledge in Military Leadership. TK = tacit knowledge.

Results show a main effect of condition on post-test scores ($F(3, 41) = 4.15, p = .01, \eta^2 = .08$). Pairwise comparisons between experimental and control groups show that mean differences between the action-focused experimental group and the control group were significant (mean difference = 1.72, $SE = .54, p = .00$ based on estimated marginal means), mean differences between the condition-focused experimental group and the control group approached significance (mean difference = .94, $SE = .53, p = .08$). Full results are displayed in Table 5. Unlike the results using the TKML as the dependent variable, mean differences between the combined condition and action-focused experimental group and the control group were not statistically significant.

Although speculative, TK case study data results are consistent with TK survey data results in support of Hypothesis 1; experimental reflection interventions improved PS2 case study scores more than the no-reflection control. However, TK case study data results were not consistent with TK survey data analyses and do not support Hypothesis 2; contrary to expectations, the combined condition- and action-focused intervention did not improve TK case study scores more than interventions that focused on either condition or action separately.

4.3. Discussion

Taken together, these findings provide tentative support for the hypothesis that TK reflection training that focuses on one or both condition and action aspects of a practical problem will improve practical problem solving more than a no-training control. The effect sizes were small but the difference between experimental and control groups was statistically significant.

Depending on the type of TK measure utilized (survey or case study), findings were varied in tests of the hypothesis that TK reflection training that focuses on both condition and action aspects of a practical problem will improve practical problem solving more than training that focuses on either aspect separately. With TK survey measures, results supported Hypothesis 2 in that the condition- and action-focused intervention group improved practical problem solving more than training that focused on either aspect separately. With the TK case study measure (PS2), results did not support Hypothesis 2; the action-focused intervention improved practical problem solving more than the combined condition- and action-focused intervention.

It is possible that the effectiveness of a particular reflection intervention may depend on the complexity of the task. TK surveys provide limited information about a specific problem situation and require assessment of specified response strategies. In contrast, TK case studies present more information and require generation of responses. Given the complexity of the case study measure and the relatively greater response demand, participants may not benefit from a brief condition-action reflection intervention. Psychometric limitations of the case study measures notwithstanding, the findings with these measures are consistent with Schön's (1983) assertion that

Table 5
Results of univariate analysis of variance with PS2 CS as dependent variable with no-training comparison.

Source	df	F	Sig.
TKML pre-test	1	0.37	.54
Experimental condition	3	4.34	.01
Error	43		
Note. $R^2 = .27$			
No-training comparison	Mean difference	SE	Sig.
Condition	−0.94	0.53	.09
Action	−1.74	0.53	.00
Combined	−0.25	0.53	.64

Note. TKML = Tacit Knowledge in Military Leadership Survey.
PS2 CS = Platoon Scenario 2 Case Study.

when faced with unexpected action outcomes in real-world situations, managers learn by “reflection-in-action”.

According to the theory of practical intelligence, skills required to solve practical problems differ from those required to solve analytic problems, primarily because the types of problems are fundamentally different (Sternberg et al., 2000). As noted earlier, practical problems tend to be related to everyday experience—unformulated or in need of formulation, poorly defined, lacking in information necessary for solution, characterized by multiple appropriate solutions, and involving multiple methods for picking an appropriate solution. In contrast, analytic problems tend to be abstract, formulated by others, well-defined, complete in the information they provide, characterized by having only one correct answer and method for obtaining the correct solution. To examine whether reflection training developed for this study would improve practical problem solving more than analytic reflection characteristic in academic classroom curricula (e.g., questions that prompt analysis and evaluation of ideas), a second study was conducted with a sample of college students.

5. Study 2: developing tacit knowledge of college life

The purpose of this study was to test Hypothesis 3, which states that tacit-knowledge reflection training that focuses on both condition and action aspects of a practical problem will improve practical problem solving more than analytic (academic-type) reflection.

5.1. Methods

5.1.1. Subjects

Participants were two hundred and thirty-five (235) undergraduates from three universities in the Northeast and one in the Northwest ranging in age from 18 to 28 years with a mean age of 18.7 years. One hundred fifty-seven (67%) were women, and 78 (33%) were men. One hundred sixty-eight (72%) were European-American, 15 (6%) were Asian American, 11 (5%) were Hispanic American, 7 were African American (3%), 14 (6%) reported themselves as “other,” and 20 (8%) did not report ethnicity. Two hundred twenty-two (94%) reported being a native English speaking, 12 (5%) were not, and one did not report language status.

5.1.2. Procedure

Participants were recruited through flyers, e-mails, and in-person announcements in undergraduate classes. Volunteers were paid (\$30) to take part in a single, three-hour session administered by two experimenters in a classroom setting. Experimental and control condition packets were randomly assigned to participants. Participants were told the purpose of the study was to assess reflection methods for developing practical problem solving using materials that focused on college life. Participants were instructed not to speak about study materials during breaks. Covariate surveys/tests, and self-paced tacit-knowledge pre-test materials were administered, followed by a short break (10–15 min). After the break, participants completed either the experimental or control self-paced reflection exercise, each of which took 25 to 35 min to complete.

The structure of the experimental intervention was similar to that in Study 1. In the experimental condition, participants were administered a self-paced *condition and action-focused* reflection intervention, in which they first read material that described the cognitive processes that underlie practical problem solving in lay terms. Then, they responded to questions designed to stimulate reflection on tacit-knowledge materials considered in the pre-test assessment. In the control condition, participants read articles on topics relevant to college life and responded to questions that required analytical reflection on the issues presented.

Following the intervention, participants took a more extended 25-minute break designed to mitigate against fatigue and provide time

for cognitive integration. During this time, food and drink were provided and participants watched a short segment of a comedy video. Following the break, they were encouraged to put forth the same level of effort as in the pre-test, and tacit-knowledge post-tests were administered. After completing the post-test, all participants completed the Satisfaction with Intervention survey.

5.1.3. Measures

College Student Questionnaire (CSQ; Sternberg et al., 2000). The CSQ is made up of vignettes that describe problem situations that may be encountered by a college student followed by a number of solutions strategies, the quality of which participants rate on a seven-point scale (1 = high quality, 7 = low quality). Two sets of six vignettes were selected, based on content to form roughly equivalent pre- and post-test blocks. Administrations of pre- and post-test blocks were counterbalanced to equate test versions. Adequate reliability and validity of these measures has been reported in Cianciolo et al. (2004). A general group-consensus approach to scoring was applied, in which scores were calculated by squaring the Euclidean distance from the group mean.

College case studies (Matthew, Cianciolo, and Sternberg, 2005). Two college life case studies, English Class (EC) and Roommate (RM), were developed for this study based on common themes and dilemmas that emerged from the interviews with college life “subject matter experts,” upperclassmen serving as residence hall advisors with demonstrated ability to succeed in college life. Two context-rich, complex, and ambiguous case studies were created to elicit variability in problem identification and solution generation. The first case study featured multiple problems associated with performance in an upper-level English class. The second case study depicted a situation in which a roommate exhibits a disruptive pattern of behavior and declining performance in school. Open-ended questions designed to measure practical problem solving and tacit knowledge were incorporated into the case study. Case study drafts were piloted and revised accordingly. Four independent, trained graduate students rated case study responses. Case studies were scored on two tacit-knowledge dimensions, content and thoughtfulness. Inter-rater reliabilities, estimated by an intraclass correlation (two-way mixed effects), were .93 for EC and .94 for RM.

Cattell Culture Fair Test of g (Cattell & Cattell, 1963). This test of cognitive ability is described previously in Study 1. The same shortened version was administered.

Mill Hill Vocabulary Scale (Raven, Raven, & Court, 1985). This test of crystallized cognitive ability was described previously in Study 1. The same shortened version was administered.

Satisfaction with Intervention survey covariate.

This survey was developed for this study to control for the effect of possible differences in satisfaction with the interventions on post-test performance. Participants are asked to rate the degree to which they agree with a series of six evaluative statements, for example, “I learned something from the intervention.” Respondents indicated the extent to which they agreed with the statement on a five-point scale (1 = strongly disagree, 5 = strongly agree).

5.2. Results

5.2.1. Initial analyses

Two cases were removed from the dataset because one participant did not complete the post-test and another had consistently inappropriate answers suggestive of a motivational problem. Internal-consistency measures were acceptable for tacit-knowledge measures. Measures of reliability for the Mill Hill and Cattell cognitive-ability tests were low, possibly because short forms of the Cattell and Mill Hill were utilized. Results are displayed in Table 6. Cognitive-ability test means were lower in the college sample as compared to the Army sample. College students may have been less motivated to perform on cognitive-ability tests. Army officers were asked by superiors to participate, which may have

Table 6
Reliability of Study 2 measures.

Measure	N	Reliability estimate
CSQ	12	.78
EC CS	8	.58
RM CS	9	.67
Mill Hill	33	.60
Cattell	24	.42

Note. Reliability estimates are Cronbach alpha values except for the Cattell, which is split-half.

CSQ = College Student Questionnaire.

EC CS = English Class Case Study.

RM CS = Roommate Case Study.

conveyed importance to the task. Alternatively, college students were offered monetary compensation that would be provided whether or not they applied themselves. Research has shown that an emphasis on extrinsic rewards for performance can decrease intrinsic motivation to perform in workers and students (Deci, Koestner, & Ryan, 1999; Heath, 1999). Tacit-knowledge inventories, which feature real-to-life problems in student life, may have been more engaging and inherently motivating than cognitive-ability tests.

Descriptive statistics and intercorrelations of tacit-knowledge measures and cognitive-ability covariates are displayed in Table 7. There were no significant mean differences between the experimental and control groups on gender, ethnicity, or covariate measures. There was no main effect of test version on the CLQ pre- and post-tests. However, there was evidence of a significant effect of interaction on case study test version of case study and pre- and post-test scores (Hotelling $T^2 = .09$, $F [1,233] = 22.1$, $p = .00$, $\eta^2 = .08$). Participants who received the English Class case study in the pre-test performed equally well on the Roommate case study post-test. Participants who received the Roommate case study in pre-test did much worse on the English Class case study post-test, suggesting that the case study measures were not equivalent.

5.2.2. Hypothesis test

To test Hypothesis 3, which predicts that the experimental reflection intervention will improve post-test tacit-knowledge scores more than the control reflection intervention, a GLM repeated measures ANOVA was conducted. Tacit-knowledge survey (CSQ) and pre- and post-test scores were the within-subject variable and

Table 7
Descriptive statistics and intercorrelations among tacit-knowledge and cognitive-ability measures.

	N	Mean	SD	1	2	3	4	5	6	7	8
1. CSQ pre-test	233			1							
2. CSQ post-test	233			.65**	1						
3. EC CS pre-test	116	24.87	3.53	.13	.10	1					
4. EC CS post-test	117	23.59	3.57	.12	.03	–	1				
5. RM CS pre-test	117	26.14	4.31	.15	.09	–	.39**	1			
6. RM CS post-test	116	24.87	3.53	.05	.07	.34	–	–	1		
7. Cattell	233	12.91	3.17	.20**	.12	.11	.30**	.10	.06	1	
8. Mill Hill	233	19.03	3.41	.07	.05	.19*	.33	.30**	.06	.13	1

Note. All correlations among scenario pre- and post-tests were not obtainable. Half the sample received version A (EC pre-test, RM post-test) and the other half received version B (RM pre-test, EC post-test).

CSQ (distance scores) correlations were reversed for ease of interpretation.

CSQ = College Student Questionnaire.

EC CS = English Class Case Study.

RM CS = Roommate Case Study.

** Correlation significant at the 0.01 level (two-tailed).

* Correlation significant at the 0.05 level (two-tailed).

experimental condition, the between-subject independent variable. This more powerful ANOVA was appropriate because random assignment to conditions was employed. The results of the repeated-measure ANOVA of condition on tacit-knowledge post-test performance approached significance (Hotellings $T^2 = .02$, $F [1, 233] = 3.47$, $p = .06$, $\eta^2 = .01$), which provides only marginal support to Hypothesis 3. Full results are displayed as follows in Table 8.

Consistent with findings in Study 1, pre- and post-test case study scores were not analyzed because initial analyses suggest they are not equivalent. For exploratory purposes the CSQ pre-test score was used in place of a case study pre-test score as a conceptually relevant proxy. Two GLM univariate analyses of variance were conducted with each case study post-test (Roommate and English Class) as the dependent variable, experimental condition as the independent variable, tacit-knowledge survey (CSQ) pre-test as covariate, with simple contrasts between the experimental and control group. The main effect of condition on TK scores was not statistically significant for either case study.

5.3. Discussion

Although the trend in Study 2 data were in the expected direction, test results closely approached but did not quite reach the level of statistical significance to support the hypothesis that TK reflection training that focuses on both condition and action aspects of a practical problem solving improves practical problem solving more than an analytic (academic-type) reflection control. The fact that these results do not replicate findings with the Army sample raises some interesting questions about the most appropriate type of reflection training on experience for the college student population. College students have less experience with solving practical problems in living. A brief combined condition and action-focused intervention may have been too complex and too short to have an effect on practical problem solving skills. In addition, college life TK survey measures may be less precise in differentiating practical problem solving as compared to military TK surveys, which have undergone more extensive psychometric analysis and differentiation in terms of levels of experience.

6. General discussion

This investigation suggests that the application of Sternberg's theory of practical intelligence to reflection methodology may be worthy of continued study. Results of the military leadership study (Study 1) provided modest support for the hypothesis that brief TK reflection training that focuses on one or both condition and action aspects of a practical problem will improve practical problem solving more than a no-training control. Trends in the data suggest that, with brief-reflection interventions, the relative effects of reflection that focuses on condition, action, or a combination of the two aspects of the tacit-knowledge model may depend on the level of task complexity. With tacit-knowledge surveys, where limited information about a specific problem situation is provided and responses involve assessment of specified response strategies, interventions that combined reflection on condition and action were effective in the military study (Study 1); the trend in the college life study data (Study 2) was in the same direction, although results did not quite reach the level of statistical significance. Although speculative, tacit-knowledge case study data (military sample, Study 1) imply that with tasks that more

Table 8
Repeated measures analysis of variance with CSQ pre- and post-test scores.

Variable	T^2	df	F	Sig.
Tacit knowledge: CSQ	.03	233	6.19	.01
Experimental condition	.02	233	3.47	.06

Note. $\eta^2 = .01$.

CSQ = College Student Questionnaire.

closely simulate the complexity of real-world situations and require the generation of a response, brief-reflection interventions that focus on either the action or condition aspect of a problem situation may be more effective than utilizing a combined approach.

6.1. Limitations

Measurement challenges represent a primary limitation of this investigation. Tacit knowledge is challenging to measure and existing measures are relatively new. These measures are domain-specific and must be customized to the particular domain under inquiry. Because these measures attempt to simulate the complexity of real-world situations, it is difficult to achieve a high degree of measurement accuracy. Reliabilities tend to be on the low side. We were not able to achieve equivalence with the two new TK case study measures developed for each of the studies. Despite the difficulties with measurement, this effort seems defensible when one considers the potential for applied gains.

Another limitation of this study is that reflection interventions were very brief. The amount of time required for reflection methods to enhance practical problem solving over time was not evaluated. Participants were engaged in reflection exercises for a brief time period (30 to 40 min). It is possible that certain methods may require more time than others to be effective. In addition, transfer of training over time was not assessed. Post-test assessments followed reflection interventions in a single session. Moreover, as stated previously, this may depend upon the nature and complexity of the task. For example, case study measures, which more closely simulate the complexity of real life issues, may require more time.

Finally, the reflection format was individual, which makes it impossible to generalize the results of reflection interventions to other types of reflection formats, such as peer group or tutor facilitated.

6.2. Implications

Although a variety of reflection methods have been advocated and used to enhance or foster the exchange of tacit knowledge in a range of workplace settings, the effectiveness of these methods may vary considerably, depending upon how they are designed and implemented. This investigation represents a first step in identifying the potential benefit of Sternberg's theory of practical intelligence as applied to reflection training using an individual-level format. Additional work using this approach seems defensible. How this approach might effect team-level reflection would be a future area worth exploring. Methods based on cognitive theory may be boosted or diminished by the influence of social factors depending on how they are designed. The different processes activated by social factors, which uniquely enhance job performance such as increased motivation or self-efficacy, may have implications on reflection design.

The focus of this investigation was on the design of instruments and model-based reflection that can be tailored to professional objectives in higher learning and professional education (Cox, 2005; Johns, 1994, 1998.) It addressed the cognitive aspect of reflection training that can be designed to make tacit knowledge explicit and available for development. Although modest, the effect of such training on practice problem solving is encouraging. The model of tacit-knowledge reflection training developed for this investigation could potentially be applied to programs that prepare students for professional practice including teacher education, counselor education, and management/leadership education. In business education, case study analysis could be augmented by applying this approach to reflection. In addition, the reflection training model can be adapted to professional-development programs in organizations, including management coaching and mentoring practices.

There is much more work to be done to verify the effect of reflection methods on learning and performance, identify the factors that mod-

erate the relationship between reflection method and effectiveness, and examine transfer of training over time. Future research that builds on this investigation is extending Study 1 design to include longer interventions with other reflection formats such as peer- or tutor-facilitated reflection and follow-up assessment of transfer of training. Examination of potential moderators might include level of experience. Seasoned professionals, whose experience may no longer be appropriate in the current environment, may require different methods than those with less experience who are just beginning to build a network of tacit knowledge in their profession.

7. Conclusion

This investigation encourages ongoing investigation of individual differences in the ability to learn from experience. It also encourages the design of tacit-knowledge reflection training that selectively develops the acquisition of tacit knowledge to enhance one's capacity to learn from experience. In particular, this research suggests the utility of future study to assess whether reflection training that specifically targets theorized cognitive processes that underlie the acquisition of tacit knowledge will enhance practical problem solving in real-world simulations. Improving our understanding of the cognitive process of on-the-job learning and ways to facilitate it may be the greatest potential contribution of Sternberg's (1997) theory in regard to practical intelligence and previous work on tacit knowledge.

What we have learned from this inquiry is that it may be possible to design very brief individual-level tacit-knowledge reflection training interventions to develop practical problem solving using Sternberg's cognitive framework. Addressing the issues of measurement, timing of interventions, and transfer of training to professional practice are critical next steps. Extending this line of inquiry to applications at the team and organization-level of learning also seems warranted. This investigation has provided some specification of cognitive factors that may have bearing on experience-based learning. Further specification of cognitive and social factors and how they interact is needed to advance the state of the art.

On-going development of cognitive and social learning theory-based methods and measures promises to enhance the capacity of professionals to learn quickly and effectively from experience, a challenge that has never been more critical to higher education and professional development than in the current workplace environment.

Acknowledgements

This research was sponsored by the U.S. Army Research Institute for the Behavioral and Social Sciences (Grant #DASW-01-K-0014).

The authors thank Anna Cianciolo for her contribution to study design and measures, Eric Goodrich, Michael Myers, and Cassandra Nichols, who contributed to the development of measures and scoring rubrics, and Jean Pretz for her input on data analysis.

Appendix A. Sample reflection training, college life

Reflection on condition and action: improving practical problem solving.

In this brief exercise we want to show you how reflecting on your thought process when confronting a practical problem can improve your ability to find the right solution. As you well know, different people can encounter the same situation but interpret it very differently. When we respond to situations in life, much of our thinking is automatic and outside of our awareness. However, just as a golfer or baseball player examines his or her swing in detail in order to improve performance, examining thinking that underlies problem solving makes it possible to improve decision-making.

On the next few pages you will be asked to reflect on one of the college life vignettes and an experience of your own. You will be

guided through a series of questions that turn your attention to how you came to understand the problems presented and how this understanding affected your decision to act. You have probably heard the phrase “think before you act”. Our objective is to help you become aware of your thinking process and develop it.

In particular, we will ask you to reflect on three fundamental components of problem solving: 1) what you define as a problem; 2) the goal or outcome you hope to achieve; and 3) what actions you expect will bring about your chosen outcome.

To illustrate these points, consider the vignette below.

One evening, you come to the dining hall and attempt to join the crowd of friends you usually eat with. You get your food, you approach the table, you are about to say “Hi, guys!” and, all of a sudden, you notice that nobody greets you and nobody smiles at you. Quite on the contrary, some people are looking down while others are just staring at you.

There are several feasible interpretations of this problem. Quite often the way we interpret a problem is directly linked to a past experience that seems similar in certain respects. Some examples are as follows:

- 1) You may interpret the problem to be that your friends are upset with you about something you have done. Perhaps you have experienced a similar situation in high school when a few of your good friends were angry with you and chose to ignore you.
- 2) Alternatively this situation may remind you of a time when, for no apparent reason at all, certain friends turned against you. This experience may lead you to interpret the current problem in a similar fashion.
- 3) A third interpretation may be that, if there is a problem, it does not necessarily involve you. Perhaps you have encountered a situation like this before when you needlessly worried about a problem that didn't involve you in the first place.

Therefore, it can be helpful to become aware of how our past experience may influence and sometimes bias how we interpret a new situation. To avoid ways that our past experience may limit our perspective, it is important to pay attention to unique factors in the new situation and consider alternative interpretations before responding.

In the above example, a course of action that you may choose to take given your particular interpretation of a situation depends upon your goal or the outcome you wish to achieve.

For example:

- 1) If you interpret the problem to be that you may have done something wrong, a goal or intended outcome might be to restore your friendship. This could lead to actions associated with finding out what's wrong so you can do something to straighten it out.
- 2) If you feel these friends are mistreating you, your goal from this perspective might be to protect yourself from being hurt. This might lead to actions associated with avoiding them.
- 3) If you feel that whatever is going on probably does not involve you your goal could be to avoid the problem entirely. This could lead to actions associated with pretending that there is nothing wrong and going about your own business.

Just as there are several ways to interpret problems that are reflected in the goals that you chose there are also several ways to reach those goals. After you have defined your problem, it is important to consider alternative actions before deciding on the best course of action. For example, an alternate approach to dealing with the problem of being mistreated by friends with the goal of protecting yourself could be to confront the issue and defend yourself.

We can improve our practical problem solving by recognizing what factors lead us to interpret a situation in a particular way, form our goals, and select actions to achieve them.

Now consider another vignette that you responded to earlier, which is reprinted with response options below to refresh your memory.

You have decided to apply for an internship during the upcoming break, and want to ask one of your professors for a letter of recommendation. The professor you have in mind is teaching a fairly large class, and he does not know you very well. One day you run into him in the coffee shop, where he is sitting with what you assume are his kids

- a) You decide that this is a good time to talk to him about the letter.
- b) You go up and greet him, reminding him of your name and what class you are in.
- c) You greet him and then start chatting with his kids.
- d) You nod but do not talk to him.
- e) You pretend you have not seen him. He probably does not want to deal with students outside of his workplace.
- f) You ask if you can sit down with him and his kids and talk about different things.
- g) You greet him and ask for an appointment with him the following day.
- h) You greet him and offer to buy him and his kids coffee or sodas.

Please respond to the following questions as if you are the student in this vignette:

- 1a) What is your interpretation of the problem to be solved in this vignette?
- 1b) What is the goal or outcome you are trying to achieve?
- 1c) What specific course of action do you think would be most useful to achieving your goal?
- 1d) How would you know if this course of action was NOT effective?
- 1e) What factors (e.g., past experience with professors, beliefs, values, etc.) do you think influenced how you interpreted the situation and selected your goal and preferred course of action?
- 1f) Think about the perspective of the faculty member. How might he interpret the situation?
- 2a) Suggest an interpretation of the problem in this vignette that is feasible but different than yours.
- 2b) What factors would you have to emphasize to arrive at this interpretation?
- 2c) Suggest a goal that might be associated with this alternative interpretation that is feasible but different than your original goal.
- 2d) Suggest a course of action that you think might be effective given this new interpretation and goal.

Now, please think about a situation you encountered in either high school or college in which your actions did NOT result in the outcome that you expected and you were challenged to reexamine your assumptions, goals, and/or actions.

- 3a) Briefly describe the problem situation. What was your interpretation of the problem, the goal you had in mind, and the action you took?
- 3b) Describe the factors (e.g., assumptions, beliefs, values, past experience, etc.) that played a role in how you defined the problem, selected your goal, and/or the action you took.
- 3c) What outcome did you expect would result from the action that you took?
- 3d) What was the actual outcome?
- 3e) What factors did you need to reconsider to change your understanding of the problem?
- 3f) In light of this new understanding, what would be your goal and how would you act differently in a situation such as this?

Recognizing that the factors we consider and emphasize play an important part in determining how we interpret problem situations: Please list at least three questions that you can ask yourself before responding to a problem situation.

Realizing that our choice of actions may be biased by assumptions, beliefs, and past experience:

Please list at least three questions that you can ask yourself before deciding on the particular course of action to take in a situation.

References

- Arbaugh, J. B., & Duray, R. (2002). Technological and structural characteristics, student learning and satisfaction with web-based courses: An exploratory study of two online MBA programs. *Management Learning*, 33(3), 331–347.
- Argyris, C. (1976). Theories of action that inhibit individual learning. *American Psychologist*, 638–654.
- Argyris, C. (1991). Teaching smart people how to learn. *Harvard Business Review*, 69(3), 99–109.
- Argyris, C. (1994). *On organizational learning*. Oxford: Blackwell Publishers.
- Argyris, C. (1999). Tacit knowledge and management. In R. J. Sternberg, & J. A. Horvath (Eds.), *Tacit knowledge in professional practice* (pp. 123–140). Mahwah, NJ: Lawrence Erlbaum Associates.
- Bapuji, H., & Crossan, M. (2004). From questions to answers: Reviewing organizational learning research. *Management Learning*, 35(4), 397–417.
- Cattell, R. B., & Cattell, H. E. P. (1963). *Measuring intelligence with the Culture Fair Tests*. Champaign, IL: Institute for Personality and Ability Testing.
- Cianciolo, A. T., Antonakis, J., & Sternberg, R. J. (2004). Practical intelligence and leadership: Using experience as a “mentor.” In D. V. Day, S. J. Zaccaro & S. M. Halpin (Eds.), *Leader development for transforming organizations* (pp. 211–236). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.
- Cianciolo, A. T., Grigorenko, E. L., Jarvin, L., Gil, G., Drebot, M. E., & Sternberg, R. J. (2006). Practical intelligence and tacit knowledge: Advancements in the measurement of developing expertise. *Learning and Individual Differences*, 16(3), 235–253.
- Cianciolo, A. T., Matthew, C. T., Wagner, R. A., & Sternberg, R. J. (2005). Tacit knowledge, practical intelligence, and expertise. In N. Charness, K. A. Ericsson, P. Feltovich & R. Hoffman (Eds.), *Cambridge Handbook of Expertise and Expert Performance*.
- Cox, E. (2005). Adult learners learning from experience: Using a reflective practice model to support work-based learning. *Reflective Practice*, 6(4), 459–472.
- Daudelin, M. W. (1996). Learning from experience through reflection. *Organizational Dynamics*, 24(3), 36–48.
- Deci, E. L., Koestner, R., & Ryan, R. M. (1999). A meta-analytic review of experiments examining the effect of extrinsic rewards on intrinsic motivation. *Psychological Bulletin*, 125(6), 627–668.
- Dewey, J. (1910). *How we think*. Boston: Heath and Co.
- Epstein, R. M. (1999). Mindful practice. *Journal of the American Medical Association*, 282(9), 833–839.
- Gherardi, S., Nicolini, D., & Odella, F. (1998). Toward a social understanding of how people learn in organizations. *Management Learning*, 29(3), 273–297.
- Heath, C. (1999). On the social psychology of agency relationships: Lay theories of motivation overemphasize extrinsic incentives. *Organizational Behavior and Human Decision Processes*, 78(1), 25–62.
- Hedlund, J., & Sternberg, R. J. (2000). Practical intelligence: Implications for human resources research. In G. R. Ferris (Ed.), *Research in Personnel and Human Resource Management*, Vol. 19. (pp. 1–52). Oxford, UK: Elsevier Science.
- Hedlund, J., Williams, W. M., Horvath, J. A., Forsythe, G. B., Snook, S., Wattendorf, J., McNally, J. A., Sweeney, P. J., Bullis, R. C., Dennis, M., & Sternberg, R. J. (1999). *Tacit knowledge for military leaders (Research Product 99-07, 99-08, 99-09)*. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.
- Hedlund, J., Wilt, J. M., Mebel, K. L., Ashford, S. J., & Sternberg, R. J. (2006). Assessing practical intelligence in business school admissions: A supplement to graduate management admissions test. *Learning and Individual Differences*, 16(2), 101–217.
- Horvath, J. A., Hedlund, J., Snook, S., Forsythe, G. B., & Sternberg, R. J. (1998). *Tacit Knowledge in Military Leadership: Some research products and their applications to leadership development (Technical Report # 1081)*. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.
- Johns, C. (1994). Guided reflection. In A. Palmer, S. Burns, & C. Bulman (Eds.), *Reflective practice in nursing* Oxford: Blackwell Science Publishers.
- Johns, C. (1998). Illuminating the transformative potential of guided reflection. In C. Johns & D. Freshwater (Eds.), *Transforming nursing through reflective practice* (pp. 78–90). Oxford: Blackwell Science Publishers.
- Kanuka, H., & Nocente, N. (2003). Exploring the effects of personality type on perceived satisfaction with web-based learning in continuing professional development. *Distance Education*, 24(2), 228–245.
- Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice-Hall.
- Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.
- Legree, P. (1995). Evidence for an oblique social intelligence factor established with a Likert-based testing procedure. *Intelligence*, 21(3), 247–266.
- Lesser, E. L., & Storck, J. (2001). Communities of practice and organizational performance. *IBM Systems Journal*, 40(4), 831–841.
- Lewin, K. (1951). *Field research in social sciences*. New York: Harper and Row.
- Marsick, V. J. (1988). Learning in the workplace: The case for reflectivity and critical reflectivity. *Adult Education Quarterly*, 38(4), 187–198.
- Marsick, V. (1990). Experience-based learning: Executive learning outside the classroom. *Journal of Management Development*, 9(4), 50–60 (Special Issue).
- Marsick, V. J., & Watkins, K. E. (1997). Lessons from informal and incidental learning. In J. Burgoyne & M. Reynolds (Eds.), *Management learning: Integrating perspectives in theory and practice* (pp. 295–311). London: Sage.
- Matthew, C. T., Cianciolo, A. T., & Sternberg, R. J. (2005). *Developing effective military leaders: Facilitation the acquisition of experience-based, tacit knowledge (Technical Report)*. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.
- Motowilo, S. J., Dunnette, M. D., & Carter, G. W. (1990). An alternative selection procedure: The low-fidelity simulation. *Journal of Applied Psychology*, 75(6), 640–647.
- Neisser, U. (1976). General, academic, and artificial intelligence. In L. Resnick (Ed.), *Human intelligence: Perspectives on its theory and measurement* (pp. 179–189). Norwood, NJ: Ablex.
- Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science*, 5(1), 14–37.
- Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation* New York: Oxford University Press.
- Polanyi, M. (1966). *The tacit dimension*. Garden City, NY: Doubleday and Company.
- Raelin, J. A. (1997). A model of work-based learning. *Organization Science*, 8(6), 563–578.
- Raelin, J. A. (2001). Public reflection on the basis of learning. *Management Learning*, 32(1), 1–11.
- Raven, J. C., Raven, J., & Court, J. H. (1985). Mill-Hill Vocabulary Scale, Junior Multiple Choice. The Psychological Corporation, Harcourt Brace Jovanovich, Inc.
- Reber, A. S. (1989). Implicit learning and tacit knowledge. *Journal of Experimental Psychology*, 118, 219–235.
- Revans, R. W. (1982). *The origins and growth of action learning*. London: Chartwell-Bratt Ltd.
- Schön, D. A. (1983). *The reflective practitioner: How professionals think in action*. Basic Books, Inc.
- Schön, D. A. (1987). *Educating the reflective practitioner*. San Francisco: Jossey-Bass.
- Seibert, K. W., & Daudelin, M. W. (1999). *The role of reflection in managerial learning: Theory, research, and practice*. Westport, CT: Quorum.
- Sternberg, R. J. (1983). Components of human intelligence. *Cognition*, 15, 1–48.
- Sternberg, R. J. (1985). *Beyond IQ: A triarchic theory of human intelligence*. New York: Cambridge University Press.
- Sternberg, R. J. (1988). *The triarchic mind*. New York: Penguin Books.
- Sternberg, R. J. (1996). *Successful intelligence*. New York: Simon and Schuster.
- Sternberg, R. J. (1997). Tacit knowledge and job success. In N. Anderson & P. Herriot (Eds.), *International Handbook of Selection and Assessment* (pp. 201–213). New York: Wiley.
- Sternberg, R. J. (1998a). Abilities are forms of developing expertise. *Educational Researcher*, 27(3), 11–20.
- Sternberg, R. J. (1998b). Principles of teaching for successful intelligence. *Educational Psychologist*, 33, 65–72.
- Sternberg, R. J. (1999). Intelligence as developing expertise. *Contemporary Educational Psychology*, 24, 359–375.
- Sternberg, R. J. (2005). The theory of successful intelligence. *Interamerican Journal of Psychology*, 39(2), 189–202.
- Sternberg, R. J., Forsythe, G. B., Hedlund, J., Horvath, H. A., Wagner, R. K., Williams, W. M., et al. (2000). *Practical intelligence in everyday life*. New York: Cambridge University Press.
- Sternberg, R. J., Forsythe, G. B., Hedlund, J., Horvath, J. A., Wagner, R. K., Williams, W. M., Snook, S. A., & Grigorenko, E. L. (2000). *Practical intelligence in everyday life*. Cambridge: Cambridge University Press.
- Sternberg, R. J., & Hedlund, J. (2002). Practical intelligence, g, and work psychology. *Human Performance*, 15(1/2), 143–160.
- Sternberg, R. J., & Horvath, J. A. (Eds.). (1999a). *Tacit knowledge in professional practice*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Sternberg, R. J., & Horvath, J. A. (1999b). *Tacit knowledge in professional practice*. Mahwah, NJ: Erlbaum.
- Wagner, R. K., & Sternberg, R. J. (1985). Practical intelligence in real-world pursuits: The role of tacit knowledge. *Journal of Personality and Social Psychology*, 49, 436–458.
- Wenger, E. (2000). Communities of practice and social learning systems. *Organization*, 7(2), 225–246.