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Learning by Thinking: How Reflection Aids Performance

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ABSTRACT

Research on learning has primarily focused on the role of *doing* (experience) in fostering progress over time. In this paper, we propose that one of the critical components of learning is reflection, or the intentional attempt to synthesize, abstract, and articulate the key lessons taught by experience. Drawing on dual-process theory, we focus on the reflective dimension of the learning process and propose that learning can be augmented by deliberately focusing on *thinking* about what one has been doing. We test the resulting dual-process learning model experimentally, using a mixed-method design that combines two laboratory experiments with a field experiment conducted in a large business process outsourcing company in India. We find a performance differential when comparing learning-by-doing alone to learning-by-doing coupled with reflection. Further, we hypothesize and find that the effect of reflection on learning is mediated by greater perceived self-efficacy. Together, our results shed light on the role of reflection as a powerful mechanism behind learning.

Keywords: learning by thinking; reflection; knowledge creation; learning; self-efficacy

By three methods we may learn wisdom: First, by reflection, which is noblest; Second, by imitation, which is easiest; and third, by experience, which is the bitterest.
Confucius

It is well recognized today that knowledge plays an important role in the productivity and prosperity of economies, organizations, and individuals. It is no wonder, then, that the concept of learning has captured the attention of scholars across a wide range of fields and disciplines. Learning is defined as a lasting change in knowledge generated by experience (Argote and Miron-Spektor, 2011; Fiol and Lyles, 1985). The literature has identified two types of learning, which are based on the source of such experience: direct learning from one's own experience and indirect learning from the experience of others (Darr, Argote, and Epple, 1995; Gino, Argote, Miron-Spektor, and Todorova, 2010; Chan, Li, and Pierce, 2014). Despite the abundance of studies on learning, most research on direct learning has focused on its factual dimension, namely the role of "doing" in explaining progress along the learning curve (for exceptions, see Nadler, Thompson, and Van Boven, 2003; Schön, 1983).

In this paper we take a less traveled road and focus on how individual learning can be augmented when individuals can not only "do" but also "think" about what they have been doing. In doing so, we depart from previous work equating direct learning with only learning-by-doing and introduce the construct of "learning-by-thinking"—i.e., learning that comes from reflection and articulation of the key lessons learned from experience. Given our interest in comparing the effectiveness of different sources of learning, we take a micro approach and study learning at the individual level. We argue that learning from direct experience can be more effective if coupled with reflection—that is, the intentional attempt to synthesize, abstract, and articulate the key lessons taught by experience. Reflecting on what has been learned makes experience more productive. We further argue that the boost in learning generated by reflection is induced by the impact of reflection on self-efficacy, defined as “the belief in one’s capabilities to organize and execute the courses of action required to manage prospective situations” (Bandura, 1995: 2). That is, we hypothesize that reflection builds one’s confidence in the ability to achieve a goal (i.e., self-efficacy), which in turn translates into higher rates of learning.

Our argument is based on dual-process theory (Evans, 1989) and its application to the learning process (Reber, 1993; Sun, Slusarz, and Terry, 2005). Dual-process theory suggests the existence of two systems of thought that underlie intuitive and reflective processing, often referred to as type 1 and type 2, respectively (Evans and Stanovich, 2013). We propose a dual-process learning model in which the automatic, unconscious process of learning generated from experience is coupled with the controlled, conscious attempt at learning.

We test our learning model using a mixed-method experimental design that combines the precision of laboratory experiments with the reach and relevance of a field study. We first test for the learning-by-thinking effect and the underlying psychological mechanism driving it in two laboratory experiments. To conceptually replicate our key findings and to map their relevance, we then turn to a field experiment that we carried out in a large business process outsourcing company in India.

Our findings suggest that reflection is a powerful mechanism by which experience is translated into learning. In particular, we find that individuals perform significantly better on subsequent tasks when they think about what they learned from the task they completed. Interestingly, we do not observe an additional boost in performance when individuals share the insights from their reflection efforts with others. Results of mediation analyses further show that the improvement in performance observed when individuals are learning by thinking is explained by increased self-efficacy generated by reflection.

Our research makes a novel contribution to the literature in several ways. First, our research adds to previous work on learning by proposing a dual-process model showing that the automatic, unconscious process of learning generated by “doing” becomes more effective if deliberately coupled with the controlled, conscious attempt at learning by “thinking.” In doing so, we extend literature claiming that the capacity to reflect on action is necessary for practitioners to learn (Schön, 1983), and provide, to the best of our knowledge, the first empirical test of the effect of reflective practice. Second, by uncovering the role of self-efficacy as the mechanism behind the effect of reflection on learning, we shed light on “the process of knowing” (Cook and Brown, 1999: 381). Our results show that by reflecting on and articulating the key lessons learned from experience, a person boosts her self-efficacy, which in turn has a positive effect on learning. In this respect, we answer the call for more research on knowledge creation as a fundamental step in the learning process (Argote, 2011). Finally, the finding that reflection aids learning outcomes supports the argument put forward by literature on the codification of tacit knowledge (Cowan, David, and Foray, 2000; Nonaka, 1994; Nonaka and Von Krogh, 2009), according to which the process of transforming tacit into codified knowledge requires a cognitive investment that generates a deeper understanding of this knowledge. We contribute to this literature by providing empirical evidence of the benefits associated with knowledge codification and uncovering the mechanisms behind them. Our findings suggest that the benefits of codification are not affected by whether its purpose is self-reflection or sharing know-how with others.

SOURCES OF LEARNING AND THE ROLE OF REFLECTION

Scholars and practitioners have long been interested in studying how individuals, teams, and organizations learn (e.g., Argote, Beckman, and Epple, 1990; Argote, McEvily, and Reagans, 2003; Fang, 2012). In the present study, given our interest in comparing the effectiveness of different sources of learning, we focus on individual learning, as this allows us to most precisely capture our phenomenon of interest. In addition, given the increasing atomization of work, the individual is the level at which much of the learning within organizations occurs (Clark, Huckman, and Staats, 2013). Individuals learn by acquiring and interpreting knowledge (Lindsay and Norman, 1977), even if not necessarily in an intentional manner (Bower and Hilgard, 1981). As explained by Fiol (1994: 404), “a person learns through developing different interpretations of new or existing information, that is, through developing (consciously or unconsciously) a new understanding of surrounding events.” Previous research has found individual learning to follow a pattern—that is, a learning curve—as a result of learning used to perform the task, learning used to adjust the task, and learning used to better learn from the task (Ellis, 1965; Newell and Rosenbloom, 1981).

In line with the pivotal role of experience for learning, previous research has thoroughly examined the role that both direct and indirect experience have in triggering the learning process (Darr, Argote, and Epple, 1995; Gino, Argote, Miron-Spektor, and Todorova, 2010; KC, Staats, and Gino, 2013). Most of this literature has tended to focus on what we call the “factual” dimension of the learning process. That is, researchers equated knowledge with experience and experience with action; hence, the notion of “learning-by-doing.”

Doing, however, is only part of the picture, as knowledge can be accumulated via other means. For instance, scholars have argued that the capacity to reflect on action is necessary for practitioners to learn (Schön, 1983). Along the same line, Nadler, Thompson, and Van Boven (2003) have shown how people may learn negotiation skills through a variety of methods (i.e. didactic learning, learning via information revelation, analogical learning, and observational learning), which involve, to a greater or smaller extent, some reflection.

A similar argument is the one put forward by literature on the codification of tacit knowledge (Polanyi, 1962), according to which codification efforts allow individuals and organizations to gain a deeper understanding of the tacit knowledge they possess as a result of the cognitive investment necessary for codification (Cowan, David, and Foray, 2000).

Despite the difficulties of codifying knowledge that is tacit into an explicit form (Berman, Down, and Hill, 2002; Nonaka and Takeuchi, 1995), previous applications and research have consistently suggested that individuals and organizations can benefit from such an effort, as in the standardized work practices seen in the Toyota Production System (Adler, Goldoftas, and Levine, 1999; Staats, Brunner, and Upton 2011).

Although reflection is a topic with high-level support, it requires further theoretical refinement and empirical attention in the management literature. It is a topic of great practical import, as many argue that time is growing increasingly scarce within organizations due to conflicting demands (Menzies, 2005; Perlow, 1999), thus requiring individuals to decide what high-value activities demand their time. Therefore, in this paper we focus on the role of reflection in triggering learning. In particular, based on dual-process theory (Evans and Stanovich, 2013), we propose a learning model in which the automatic, unconscious process of learning generated from experience is coupled with the controlled, conscious attempt at learning by reflection.

Towards a Dual-Process Learning Model: Reflection and Learning-by-Thinking

As Evans and Stanovich (2013: 223) put it, "the distinction between two kinds of thinking, one fast and intuitive, the other slow and deliberative, is both ancient in origin and widespread in philosophical and psychological writing." Dual-process theory suggests the existence of two systems of thought that underlie intuitive and reflective processing.

In particular, type 1 processes are defined as intuitive ones that do not require working memory and that are typically described as fast, non-conscious, automatic, associative, and independent of cognitive ability. They are associated with experience-based decision making and implicit learning. Type 2 processes, by contrast, are defined as reflective processes that require working memory, and they are typically described as slow, conscious, controlled, rule-based, and correlated with cognitive ability. They are associated with consequential decision-making and explicit learning.

In the case of learning, as Mathews *et al.* (1989: 1098) point out, dual-process theory implies that "subjects draw on two different knowledge sources to guide their behavior in complex cognitive tasks; one source is based on their explicit conceptual representation; the second, independent source of information is derived from memory-based processing, which automatically abstracts patterns of family resemblance through individual experiences."

Interestingly, recent years have witnessed an increasing interest in the interplay between these two types of learning, following the observation that nearly all complex real-world skills involve a mixture of explicit and implicit learning, and that even in the laboratory one can at best manipulate conditions to emphasize one type over the other (see Sun, Slusarz, and Terry, 2005, for a comprehensive treatment of the issue of interaction between implicit and explicit learning).

Building on this distinction and the recognition of an interaction between the two types of learning, we argue that the automatic, unconscious process of learning generated by doing can become more effective if deliberately coupled with controlled, conscious attempts at learning-by-thinking. In particular, we expect individuals to perform significantly better on subsequent tasks when they think about what they learned from the task they completed. Thus, we hypothesize:

> **Hypothesis 1**: Learning generated by reflection coupled with experience will lead to greater improvement in problem-solving capacity as compared to learning generated by experience alone.

Unpacking Learning-by-Thinking: A Teaching Effect?

Knowledge flows stimulate innovation and progress, thus benefiting society as a whole. The dissemination of knowledge, however, comes with a cost. If knowledge holders are to appropriate exclusively the private value of their knowledge, it is reasonable to expect them to avoid its leakage. Given this perspective, what would be their incentive to share knowledge with others? Most arguments on the benefits of knowledge sharing to the knowledge holder hinge on reciprocity (Kogut, 1989; Van Wijk, Van Den Bosch, Volberda and Heinhuis, 2005): A knowledge holder could benefit from sharing knowledge with a recipient because, if the recipient reciprocates, the holder may benefit from the exchange (Schrader, 1991). However, not all unilateral transfers can be expected to become bilateral exchanges. Further deepening our understanding of drivers of knowledge sharing, research on open source software environments has found that individuals may share knowledge to build their reputation or because they enjoy the sharing process (Lakhani and von Hippel, 2003; Wasko and Faraj, 2005).

Theories of knowledge codification (Cowan, David, and Foray, 2000; Nonaka, 1994; Nonaka and Von Krogh, 2009) shed light on another potential benefit to the knowledge holder of sharing knowledge. Those theories suggest that the reflection effort needed to create the insights to be shared with a counterpart may end up generating a deeper understanding of the problem space itself. This deeper understanding benefits the knowledge holder in terms of improved problem-solving capacity. In particular, we would expect the improvement in problem-solving capacity generated by reflection aimed at sharing to be greater than the improvement generated by reflection alone. In other words, one can expect performance to increase the most when reflection and sharing, i.e., thinking and teaching, are coupled. This line of argument should be familiar to those who teach and subscribe to the adage that one learns the most on a subject by being forced to teach it.

It is important to note that we are not interested in the reasons behind the choice to share knowledge. Absent reciprocity, one may decide to share information to improve one’s reputation in the community, increase one’s professional standing in the eyes of the receiver, generate a “debt” that may prove useful in the future, or simply out of altruism. In the extreme, knowledge disclosure may simply be the norm in the industry, and actors may comply with it without even thinking about whether it is beneficial or not (e.g. Haas and Park, 2010; Merton, 1973). We are interested in determining the cognitive benefit generated by knowledge sharing. Independent of why a knowledge holder decides to transfer knowledge, if these arguments are correct, then the knowledge holder will automatically end up receiving this benefit after transfer. Accordingly, we hypothesize:

> **Hypothesis 2A**: Learning generated by reflection *and* sharing coupled with experience will lead to a greater improvement in problem-solving capacity compared to learning generated by experience alone.

> **Hypothesis 2B**: Learning generated by reflection *and* sharing coupled with experience will lead to a greater improvement in problem-solving capacity compared to learning generated by reflection coupled with experience.

Unpacking Learning-by-Thinking: The Role of Self-efficacy

We have hypothesized that individuals will learn more effectively when they are given the chance to reflect and articulate the key lessons learned from experience, and that this effect will be greater when reflection efforts are aimed at sharing such key lessons with others. But why do reflection efforts generate an improvement in problem-solving capacity? We propose that the link between learning-by-thinking and greater performance is explained by self-efficacy, or a personal evaluation of one's capabilities to organize and execute courses of action to attain designated goals (Bandura, 1977). Put more simply, self-efficacy refers to confidence in one's ability to achieve a goal. In fact, the perception that one is efficacious is not based on whether one feels one has the skills and abilities to succeed. Rather, it mainly concerns what one believes one can do with the skills and abilities one may possess (Bandura, 1986). Thus, self-efficacy represents individuals' expectations and convictions of what they can accomplish in given situations. For example, the expectation that a person can high-jump 6 feet is a judgment about perceived efficacy (Bandura, 1986). It is not a judgment of whether the person is competent in high-jumping in general, but a judgment of how strongly the individual believes she can successfully jump that particular height under the given circumstances.

Psychologists have long argued that the desire to feel competent and capable is a basic human motivation (White, 1959; Ryan and Deci, 2000). Self-efficacy, it has been suggested, predicts individuals' thoughts, emotions, and actions. When people experience self-efficacy in an activity, they devote more time and energy to it because they believe that their effort will translate into success (Bandura, 1977; Ryan and Deci, 2000). Self-efficacy is also "an essential motive to learn" (Zimmerman, 2000: 82). For instance, prior research has demonstrated that self-efficacious students select more challenging tasks (Bandura and Schunk, 1981), exert more effort (Schunk and Hanson, 1985; Schunk, Hanson, and Cox, 1987), and have less adverse reactions when faced with difficulties (Bandura, 1997). As a result, self-efficacious students consistently show higher academic achievement as compared to inefficacious ones (Multon, Brown, and Lent, 1991).

Information that shapes one's self-efficacy beliefs comes from various sources (Bandura, 1986, 1997). The main and most reliable source is one's own prior experiences with the tasks in question (Bandura, 1986, 1997). Reflecting on one's past experience on the same or similar tasks and to articulate the key lessons learned from them can strengthen one's self-efficacy by allowing them to feel comfortable and confident that they can successfully perform such tasks going forward. Though it is often the case that one's past experience includes ambiguities and errors, individuals tend to focus on their strengths and positive aspects when evaluating past experiences so that they can maintain a positive view of themselves (e.g., Taylor, 1991). People often do not exert effort on tasks or problems if they feel uncertain about whether they will complete them competently and effectively (Rosen, Mickler, and Collins, 1987). Reflection, we suggest, reduces a person's experience of uncertainty about being capable to complete tasks competently and effectively. As a result, the person will exert more effort in subsequent tasks.

In short, we expect reflection to increase one's perceived self-efficacy, which in turn will lead to improvement in problem-solving capacity. In other words, self-efficacy mediates the relationship between reflection efforts and learning outcomes. Accordingly, we hypothesize:

> **Hypothesis 3**: Individuals' perceptions of self-efficacy will mediate the effect of learning generated by reflection coupled with experience on problem-solving capacity.

Overview of the Present Research

Our hypotheses suggest that when individuals reflect on their task performance and share their insights with others they perform better on subsequent tasks as compared to individuals who do not reflect, even when they have had more time to practice on the first task. This occurs because reflection increases their self-efficacy. As such, it is important to both: (a) test whether outcomes are differentially affected by alternative ways of reflecting (i.e., reflection alone versus reflection and sharing) and then (b) demonstrate why such effects occur (i.e., heightened perceived self-efficacy).

To test our hypotheses, we conducted three studies using both laboratory and field data. In Studies 1 and 2, we tested our hypotheses using two laboratory experiments. In Study 3, we conducted a field experiment with employees at a large business-process outsourcing firm to constructively replicate the tests of our hypotheses in a real-world context and provide further evidence for our proposed mechanism. The use of laboratory and field experiments offers us complementary strengths and weaknesses. The laboratory experiments allow us to identify causality, control for numerous factors, and also precisely measure our proposed mechanism. The field experiment provides a platform to not only identify causality but also to establish external validity. Together this approach allows us to more confidently evaluate our research model.

STUDY 1: LABORATORY EXPERIMENT

Method

Participants. We recruited 202 adults on MTurk (60% male, M_{age}=27.56, SD=6.75) to participate in an online study in exchange for $1 and the potential to earn an additional bonus based on performance. Specifically, ten percent of the participants (chosen randomly) received a bonus based on their performance in the study.

Design. Participants were randomly assigned to one of three conditions: control, reflection, and sharing.

Procedure. We told participants that they would complete a brain-teaser under time pressure. The brain teaser was a series of five "sum-to-ten game" grids (initially developed by Mazar, Amir, and Ariely, 2008). Each grid was a 3 x 4-cell matrix of numbers (e.g., 5.43; see Figure 1 for an example). We gave participants 20 seconds to find the two numbers in the grid that summed to ten. Participants would earn $1 for each correct brain teaser solved in 20 seconds or less (if they were among the ten percent selected at the end of the study).

[Insert Figure 1 about here]

Participants first completed a practice round to gain familiarity with the task. They then completed the first round of the brain teaser (i.e., a set of five different grids). After each grid they were told whether the answer they selected was correct or not.

We introduced our manipulation after the first round of the brain teaser. Participants in the control condition received the following instructions:

> You will now be asked to complete the second round of the MATH BRAIN TEASER. As before, you will have 20 seconds to find the right solution in each of the five math puzzles in this round.

Participants in the reflection condition received the following instructions:

> Please take the next few minutes to reflect on the task you just completed. Please write about what strategies if any you used as you were working on the task. Also

> please write about what you think one can do to be effective in solving the math problems included in this task. Please be as specific as possible. When done, click on "Next."

Finally, participants in the sharing condition received the following instructions:

> Please take the next few minutes to think about the task you just completed. Please write about what strategies if any you used as you were working on the task. Also please write about what you think one can do to be effective in solving the math problems included in this task. Please be as specific as possible. **PLEASE NOTE: Your notes will be shared with other participants who are asked to work on the same Brain Teaser task.** When done, click on "Next."

In the reflection and sharing conditions, we did not set a precise time limit for people to reflect so that we could provide a conservative test of our first two hypotheses. By keeping the amount of time to reflect unspecified, we expected more variance in the effort participants exerted thinking and writing about their learnings.

After the manipulation, participants completed two other rounds, each comprising five different grids. Our primary dependent variable of interest was participants' performance in the two rounds of the brain teaser that followed our manipulation.

Results

Table 1 summarizes the descriptive statistics of the main variables assessed in the study by condition.

We conducted an ANOVA using participants' performance on the second round of the brain teaser as the dependent measure and condition as the independent variable, and controlling for performance on the first round (before our manipulation occurred). We found a significant effect of our manipulation on performance in the second round, F (2, 198) = 5.47, p = .005, η^2_p = .05. Participants correctly solved more grids in the second round in the reflection condition (M = 2.71, SD = 1.26) and in the sharing condition (M = 2.90, SD = 1.40) than they did in the control condition (M = 2.29, SD = 1.13; p = .037 and p = .001, respectively). Performance did not differ for participants in the reflection condition and those in the sharing condition. As one may expect, performance in round 1 predicted performance at time 2, F (2, 198) = 26.56, $p < .001$, $\eta^2_p = .12$.

We conducted another ANOVA using participants' performance on the third round of the brain teaser as the dependent measure and condition as the independent variable, and controlling for performance on the first and the second round. We found a significant effect of our manipulation on performance in the third round, F (2, 198) = 5.03, $p = .007$, $\eta^2_p = .05$. Participants correctly solved more grids in the third round in the reflection condition (M = 2.74, SD = 1.32) and in the sharing condition (M = 2.96, SD = 1.29) than they did in the control condition (M = 2.25, SD = 1.40; $p = .05$ and $p = .002$, respectively). Performance did not differ between participants in the reflection condition and those in the sharing condition. Both performance in round 1 (F (2, 198) = 72.78, $p < .001$, $\eta^2_p = .27$) and performance in round 2 (F (2, 198) = 81.29, $p < .001$, $\eta^2_p = .29$) predicted performance at time 3.

[Insert Table 1 about here]

Discussion

These results provide initial support for our main hypothesis that *reflection* improves *performance* (H1). In fact, these beneficial effects seem to be lasting. Importantly, despite the fact that we found support for our prediction that *sharing* improves *performance* (H2a), we did not find significant differences between the effect of reflection efforts aimed at sharing and that of reflection efforts per se – in other words, we did not find significant differences between *sharing* and *reflection*, and our results did not provide support for H2b.

In this study, participants were paid for their performance. In the next study, we remove this component to test whether the beneficial effects of reflection on performance also occur when participants are paid a flat fee for their participation.

Study 2 also uses a different sample to test the generalizability of our findings and includes a measure for self-efficacy to provide evidence for the psychological mechanism driving our effects (H3).

STUDY 2: DO INCENTIVES FOR PERFORMANCE MATTER?

Method

Participants. We recruited 178 students (47% male, M_{age}=21.87, *SD*=3.75) from local universities in a city in the Northeastern Unites States. Participants received $15 for their participation.

Design and procedure. We used the same design and procedure as in Study 1, but this time there were ten grids in each round rather than just five. Thus, participants solved ten grids prior to our manipulations and 20 grids afterwards. Importantly, participants were not paid based on their performance in this study. Rather, they were paid a flat fee. Study 2 also included a measure assessing participants' self-efficacy after the manipulation occurred. We assessed self-efficacy with a four-item scale adapted from Bandura (1990), which asked participants to indicate the extent to which they felt capable, competent, able to make good judgments, and able to solve difficult problems if they tried hard enough (α = .93).

Results

Performance. We used participants' performance on the brain teaser in a mixed ANOVA with type of rounds (prior to manipulation vs. afterward) as a within-subjects factor and condition (control vs. reflection vs. sharing) as a between-subject factor. As expected, this analysis revealed a main effect for the within-subjects factors, suggesting that learning occurred across rounds, F (1, 175) = 672, p < .001, η^2_p = .79. More interestingly, we found a significant interaction between type of rounds and condition, F (2, 175) = 4.99, p = .008, η^2_p = .05 (see Figure 2). The main effect for condition did not reach significance, F (2, 175) = 2.20, p = .114, η^2_p = .025.

When controlling for performance in the first set of ten rounds, we found a significant main effect of condition on performance in the rounds following the manipulation, F (2, 174) = 4.93, p = .008, η^2_p = .054. Participants correctly solved more grids in the rounds following the manipulation in the reflection condition (*M* = 12.10, *SD* = 4.80) and in the sharing condition (*M* = 12.33, *SD* = 4.30) than they did in the control condition (*M* = 10.32, *SD* = 4.32; *p* = .011 and *p* = .005, respectively). Performance did not differ for participants in the reflection condition and those in the sharing condition.

[Insert Figure 2 about here]

Self-efficacy. We used participants' perceived self-efficacy in an ANOVA with condition (control vs. reflection vs. sharing) as a between-subject factor. As expected, this analysis revealed a main effect for our manipulation, F (1, 175) = 3.33, p = .038, η^2_p = .037. Participants reported feeling more efficacious following the manipulation in the reflection condition (*M* = 5.17, *SD* = 1.37) and in the sharing condition (*M* = 5.13, *SD* = 1.47) than they did in the control condition (*M* = 4.56, *SD* = 1.41; *p* = .022 and *p* = .032, respectively). Perceived self-efficacy did not differ for participants in the reflection condition and those in the sharing condition (*p* = .088).

Mediation analyses. To examine whether self-efficacy mediated the effect of reflection on performance, we followed the steps recommended by Baron and Kenny (1986). The first and second criteria specify that the independent variable should significantly affect the dependent variable and the mediators. The prior analyses showed that these two criteria were met, as reflection had a significant effect on performance in the rounds following the manipulation and self-efficacy. To assess the third and fourth criteria, we conducted a hierarchical ordinary least-squares (OLS) regression analysis (controlling for performance in the first set of rounds and including a dummy variable for the sharing condition) predicting performance from the independent variable of reflection condition (Step 1) and self-efficacy (Step 2). The third criterion specifies that the mediator should significantly predict the dependent variable while controlling for the independent variable. The results met this criterion: Having dummy-controlled the reflection, we found that self-efficacy significantly predicted higher performance (β = .37, t = 5.88, $p < .001$).

To complete the test of mediation for self-efficacy, the fourth criterion holds that the effect of the independent variable on the dependent variable should decrease after controlling for the mediator. After controlling for self-efficacy, the effect of reflection on performance decreased significantly (from β = .17, t = 2.58, $p = .011$; to β = .10, t = 1.66, $p = .099$). To test whether the size of the indirect effect of reflection on performance through self-efficacy differed significantly from zero, we used a bootstrap procedure to construct bias-corrected confidence intervals based on 10,000 random samples with replacement from the full sample (Preacher and Hayes, 2004). The 95% bias-corrected confidence interval excluded zero (0.20, 1.27), indicating a significant indirect effect. Thus, self-efficacy mediated the effect of reflection on improved performance. We note that self-efficacy also mediated the relationship between sharing and performance: After controlling for self-efficacy, the effect of sharing on performance decreased significantly (from β = .19, t = 2.84, $p = .005$ to β = .13, t = 2.05, $p = .042$), and the indirect effect was significant (95% bias-corrected CI = [0.11, 1.18]).

Discussion

Together, these results are consistent with hypothesis 1: even in the absence of incentives for greater performance, reflection improved performance. Perceptions of greater self-efficacy explained this relationship. Further, we did not find a significant difference in performance between the reflection and the sharing condition.

As our final study, we moved to the field to constructively replicate our findings.

STUDY 3: FIELD STUDY

Sample and Procedures

Our final study was completed at Wipro BPO, an India-based global leader in the business-process outsourcing industry. Wipro provides knowledge-based customer support and back-office services (e.g., data entry and data processing) for its global customer base.

We conducted our field study using one customer account. The work for this account involved answering technology-related support questions via the telephone for customers of a Western technology company.

The call center provides us with an excellent setting to study learning and productivity at the individual level. Successful completion of the work requires technical knowledge on the part of Wipro employees. Questions can cover a wide range of topics; some are answered easily, while others require a great deal of problem solving. To complete the work, Wipro not only recruits well-qualified agents (college graduates) but also then trains them for four weeks on the technical process they will follow once they join the firm (known as "process training"). After technical process training, workers go through two weeks of on-the-job training, a combination of classroom training and answering actual calls. At the end of their training, workers transition full-time into their customer service responsibilities.

For our field study sample, we utilized workers who joined Wipro BPO in the focal account between June and August 2013. Workers joined in batches of 10 to 25 workers, and each batch was assigned to one of three conditions: (1) reflection, (2) sharing, and (3) control. Each group represents a similar profile of employees in terms of age, experience and other background qualifications that influence performance. Each group went through the same overall technical training. The primary difference was that workers in the reflection and sharing conditions spent the last 15 minutes of their day performing the tasks associated with our experimental manipulations.

In the reflection group, on the sixth day of training, workers were given a paper journal and asked to spend 15 minutes reflecting on the day's activities. The exact instructions provided by their Wipro trainer were:

> Please take the next 15 minutes to reflect on the training day you just completed. Please write about the main key lessons you learned as you were completing your training. Please reflect on and write about at least two key lessons. Please be as specific as possible.

Agents were given time to reflect at the end of each day for a total of 10 days. A survey was administered at the end of process training to collect data on perceptual measures (i.e., self-efficacy), and operational data was collected both during training (i.e., the score each individual got on the assessment test at the end of training) as well as after training, once an agent "hit the floor" and began serving customers (i.e., operational measures for job performance). This data is described in greater detail below.

Agents assigned to the sharing condition were asked to both reflect and share. In particular, they were instructed to:

> Please take the next 10 minutes to reflect on the training day you just completed. Please write about the main key lessons you learned as you were completing your training. Please reflect on and write about at least two key lessons. Please be as specific as possible. When done, you will be given another 5 minutes to explain these to another participant who is completing the training process with you.

Agents were given time to reflect and share at the end of each day for a total of 10 days. The same survey was administered and the same data was collected as in the sharing condition.

Finally, in the control condition, agents completed their normal activities, as training had been run previously, with no reflection or sharing intervention. Agents in the control condition did not receive additional training. Instead, in the reflection and sharing interventions, trainers were asked to adjust their timing during the day to free up the last 15 minutes for the intervention. The same survey was administered and the same data was collected as in the sharing and reflection conditions.

Empirical Strategy

As in our second study, we first test the effects of learning-by-thinking and learning-by-teaching on problem-solving capacity. Then, we look at the mechanism behind the effect of reflection on performance. As a consequence, we have four types of variables in this study. Our independent variables are learning generated by reflection coupled with experience (*reflection*, H1), and learning generated by reflection aimed at sharing the resulting insights with others, coupled with experience (*sharing*, H2). As explained above, we manipulate both of them experimentally, by allocating our participants to three alternative conditions: *reflection*, *sharing*, and *control*.

Our ultimate dependent variable is the improvement in problem-solving capacity (*performance*). We measure this variable by collecting performance data on the test our participants took at the end of their process training. This is a test administered directly by Wipro at the end of each process training in order to assess the extent to which trainees have learned the main lessons taught during the training. Scores go from 0 to 100, and were provided to us directly by the company.

We also have a mediating variable, namely individuals' perceptions of self-efficacy (*self-efficacy*, H3). We measure this variable using a five-item scale adapted from Schwarzer and Jerusalem (1995), which asked participants to indicate the extent to which they felt: (1) able to solve difficult problems if they tried hard enough; (2) capable of sticking to their aims and accomplishing their goals; (3) confident that they could deal efficiently with unexpected events; (4) able to find several solutions when confronted with a problem; and (5) able to handle whatever would have come their way ($\alpha = .78$). We used this measure rather than the items from Study 2 since it is more specific and appropriate for a field setting. We collected this information through a survey administered to all of our participants at the end of their process training, independently of the condition to which they were allocated.

Finally, in our analyses, we include a series of controls at the individual level, namely *age* (years), *gender* (male=1, female=0), and previous work *experience* (months).

Table 2 lists our variables with details on their operationalization.

[Insert Table 2 about here]

Results

Table 3 reports descriptive statistics and correlations among the variables we collected. Finally, we report mean comparisons across participants allocated to the three different experimental conditions in Tables 4, 5 and 6. It is worth noting that participants in the different experimental groups did not differ significantly in terms of age and work experience. However, we do observe a higher number of female participants allocated to the reflection condition compared to both the control condition (Table 4) and the sharing condition (Table 6). However, *gender* is poorly correlated with any other variable and does not significantly predicts our mediating and dependent variable, as shown in Table 7.

[Insert Tables 3, 4, 5, and 6 about here]

Performance. In order to analyze results from our field experiment, we run an ordinary least squares (OLS) regression, in which we estimate the effect of *reflection* and *sharing* on *performance* in comparison with the control group.[1] Table 7 shows five models: model 1 includes only control variables; model 2 includes our independent variables *reflection* and *sharing* while omitting the variable *control*, which acts as the baseline; model 3 replicates the previous one and adds our mediating variable (*self-efficacy*); model 4 includes *sharing* and *control* while omitting *reflection*, which acts as the baseline; and finally model 5 replicates model 4 with the addition of *self-efficacy*.

Results from Model 2 show strong support for H1 and H2a: participants in both *reflection* and *sharing* conditions displayed a significant increase in *performance* compared to the control group. In particular, by being allocated to the reflection condition, participants improved their score on the final assessment test of 15.1 points – that is, a 22.8% increase with respect to the average score for the entire sample (66.1). Analogously, by being allocated to the sharing condition, participants improved their score on the final assessment test of 16.5 points – that is, a 25.0% increase with respect to the average score for the entire

[1] As a test of robustness, we also used an alternative logit specification using a dichotomous dependent variable, *passed,* indicating whether our participants passed the final assessment test or not. This pass/fail evaluation was again provided directly by Wipro. Results based on this alternative specification are consistent with those presented in the paper.

sample.

Results from Model 4, consistent with our laboratory studies, show a directional but non-significant differential effect of *sharing* compared to *reflection*, thus providing no support for H2b. Model 3 shows that the effect of *reflection* on *performance* continue to hold even when we insert our mediator, thus suggesting a partial mediation effect. We next ran a number of additional analyses aimed at testing our mediation hypothesis.

[Insert Table 7 about here]

Mediation analyses. According to H3, we expect self-efficacy to mediate the relationship between reflection and the improvement in problem-solving capacity. In particular, we expect that higher reflection will increase one's self-efficacy and that this will in turn be associated with higher performance on the final assessment test.

Consistent with H3, we find that *self-efficacy* significantly mediates the relationship between reflection and learning. In fact, *reflection* significantly predicted both *self-efficacy* ($\beta = 0.162$, $t = 1.68$, $p = 0.096$) and performance on the final assessment test ($\beta = 15.076$, $t = 5.23$, $p < 0.001$), and *self-efficacy* predicted *performance* when controlling for *reflection* ($\beta = 7.256$, $t = 2.99$, $p = 0.003$). Finally, after controlling for *self-efficacy*, the effect of *reflection* on *performance* decreased (from $\beta = 15.076$, $t = 5.23$, $p = 0.000$; to $\beta = 13.880$, $t = 4.90$, $p = 0.000$). Next, we used the bootstrapping approach developed by Preacher and Hayes (2004), based on the bootstrapped estimate of the indirect effect using 10,000 bootstrap re-samples and a bias-corrected 95 percent confidence interval (Preacher *et al.*, 2007). This technique produced a confidence interval for the indirect effect that excluded zero (2.09, 14.69), thus suggesting a significant indirect effect.

Discussion

These results provide further support for our prediction that *reflection* improves *performance* (H1) and that *self-efficacy* explains this relationship (H3). In addition, as in our first study, these findings show that the beneficial effects of reflection are lasting over time, since we observed performance benefits two weeks after the manipulation occured. As in our first two laboratory studies, we provide only partial support for H2, as we did find significant differences between sharing and control (H2a) but not between sharing and reflection (H2b).

GENERAL DISCUSSION

Over the last few decades, knowledge work—that which is built around the labor of the mind—has become an increasingly important component of advanced industrialized economies (e.g., Powell and Snellman, 2004). The rise of the so-called "knowledge economy" means that individuals face growing pressures to learn new skills and hone existing ones. At the same time, intensifying competitive pressures and other social trends have increased the pace at which we live and work.[2] As Perlow (1999: 57) puts it, many "types of workers routinely work seventy- or eighty-hour weeks, putting in extra effort during particularly hectic times."

Data show that between 1973 and 2000, "the average American worker added an additional 199 hours to his or her annual schedule – or nearly five additional weeks of work per year (assuming a 40 hour workweek)" (Schor, 2003: 7). In the meanwhile, between 1969 and 2000, "the overall index of labor productivity per hour increased about 80 percent, from 65.5 to 116.6" (Schor, 2003: 10). As a result, productivity and time efficiency have become significant concerns in modern Western societies, with time being perceived as "the ultimate scarcity" (e.g., Gross, 1987)—a valuable resource to guard and protect (Gleick, 2000; Zauberman and Lynch, 2005). In our daily battle against the clock, taking time to reflect on one's work would seem to be a luxurious pursuit.

Though some organizations are increasingly relying on some group reflection (e.g., "after-action reports"), there has been almost no effort to encourage individuals to reflect, and

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[2] Consider, for instance, the amount of information that we could potentially absorb nowadays, thanks to IT and the Internet. According to Eric Schmidt, executive chairman of Google, it now takes two days to generate the same amount of information generated between the dawn of civilization through 2003 (Pariser, 2011).

people often fail to engage in self-reflection themselves. Though reflection entails the high opportunity cost of one's time, we argue and show that reflecting after completing tasks is no idle pursuit: it can powerfully enhance the learning process. Learning, we find, can be augmented if one deliberately focuses on *thinking* about what one has been doing. In addition to showing a significant performance differential when comparing learning-by-doing alone to learning-by-doing coupled with reflection, we also demonstrate that the effect of reflection on learning is mediated by greater self-efficacy.

Across our studies, we also included a condition in which people shared their reflections with others. Interestingly, our results show that while sharing one's learning improves one's subsequent performance, the value of sharing is no different than that of reflecting and keeping one's thoughts to oneself. This is contrary to our prediction of a significant "teaching effect", and seems to show that the crucial aspect is reflection per se, independently of the aim for which reflection efforts are generated. We believe that this point deserves attention, and future research is needed in order to clarify whether there are conditions under which the "teaching" component becomes more relevant.

Theoretical and Practical Implications

We believe our research contributes to extant literature along three dimensions. First, our finding on the effect of reflection on problem-solving capacity speaks to previous studies on learning (Darr, Argote, and Epple, 1995; Gino, Argote, Miron-Spektor, and Todorova, 2010; KC, Staats, and Gino, 2013), by showing that individual learning can be augmented when individuals can not only "do" but also "think" about what they have been doing. In doing so, we depart from previous work equating direct learning with only learning-by-doing and introduce the construct of "learning-by-thinking"—i.e., learning that comes from reflection and articulation of the key lessons learned from experience.

Second, by showing that self-efficacy acts as the mechanism behind learning-by-thinking, we shed light on the process behind the creation of knowledge. Such process view contributes to a better understanding of the actual act of apprehending (Cook and Brown, 1999: 381) and answers the call for more research on knowledge creation (Argote, 2011).

Third, we contribute to literature on tacit knowledge and its codification (Cowan, David, and Foray, 2000; Nonaka, 1994; Nonaka and Von Krogh, 2009; Zollo and Winter, 2002), by providing empirical evidence of the benefits associated with knowledge codification and uncovering the mechanisms behind them.

Our results also have important practical implications. In our field study we showed that taking time away from training and reallocating that time to reflection actually improved individual performance. Companies often use tools such as learning journals as a way to encourage reflection in training and regular operations. Our personal experience is that individuals of all ages may not treat these exercises with much seriousness; however, our findings suggest that they should. Our study highlights that it may be possible to train and learn “smarter”, not “harder”. Additional work is needed to understand how reflection can be incorporated more broadly into both training and regular operations.

Limitations and Directions For Future Work

Despite our efforts, our results are subject to several limitations. First, despite the fact that we combine the use of laboratory experiments with a field study, additional research is needed to explore these findings across a broader array of contexts and tasks. Second, our research focused on individual learning, and except for one condition in the field study, participants were removed from social interactions. Understanding how social interaction may aid or detract from reflection and learning is worth additional study.

We believe our research opens a number of avenues for future investigation. First, the finding that self-efficacy only partially rather than fully mediates the relationship between reflection and improvements in problem-solving capacity generates the need for additional studies trying to better “unpack” what reflection is, how it works, and through which avenues it influences our ability to learn.

Second, in our studies, we find that learning-by-teaching does not provide additional improvements in problem-solving capacity compared to learning-by-thinking. This suggests the need to clarify if there are conditions under which the “teaching” component becomes more relevant (e.g., with more complex, difficult to codify knowledge).

Third, and relatedly, future work could better map the effect of time in the attempt to understand to what extent different sources of learning (doing, thinking, teaching) produce improvements that last over time, and whether there are differences among them. In addition, reflection may produce benefits not only for the tasks one reflected on, but also for related others. Zollo and Winter (2002) argued that knowledge codification is an important element in building capabilities. Future research examining the role of reflection in building capability would deepen our understanding of the benefits of learning-by-thinking.

Fourth, future research could examine potential boundary conditions for the effects we demonstrated across our studies by focusing on individual differences that moderate the effectiveness of reflection on learning. For instance, it would be interesting to investigate whether the effects of learning-by-thinking are stronger or weaker for people with high rather than low self-esteem, or with more rather than less task experience. Reflection may be most beneficial for people with low self-esteem, who may be unaccustomed to taking the time to codify their learnings even when they do not have a lot of task experience. For these people, in fact, reflecting may point to important aspects of their prior performance that they would not naturally think about. However, the opposite may also occur if individuals with low self-esteem have a hard time finding strengths in their prior performance.

Finally, our research focused on the beneficial effects on performance of different types of learning at the individual level. A possible extension would be to see how these effects interact with group dynamics when reflection becomes a collective effort, as it is sometimes done in companies through formal "after action" reviews (Goh, Goodman, and Weingart, 2013). More generally, future research could extend the study of reflection to better understand how it can impact other variables. For instance, the notion that reflection favors progress along the learning curve may inform research on employee motivation, and the role of work progress as one of its key drivers (Amabile and Kramer, 2011).

Conclusion

Research on learning has primarily focused on the role of *doing* (experience) in fostering progress over time. Drawing on dual-process theory, in this paper we focused on the reflective dimension of the learning process and argued that individual learning is enhanced by deliberately focusing on *thinking* about what one has been doing. Using a mixed-method approach that combines laboratory and field experiments, we find support for this prediction. Further, we find that the effect of reflection on learning is mediated by greater perceived self-efficacy. Together, our results reveal reflection to be a powerful mechanism behind learning, confirming the words of American philosopher, psychologist, and educational reformer John Dewey: "We do not learn from experience...we learn from reflecting on experience."

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Table 1. Means (and standard deviations) of main variables assessed in the study by condition, Study 1.

	Performance in Round 1	**Performance in Round 2**	**Performance in Round 3**
Control	2.22 (1.26)	2.29 (1.13)	2.25 (1.40)
Reflection	2.16 (1.18)	2.71 (1.26)	2.74 (1.32)
Sharing	2.03 (1.03)	2.90 (1.40)	2.96 (1.29)

Table 2. Variables and measures, Study 3.

Variable	Measure	Operationalization
	Dependent Variable	
Performance	Score on the final assessment test administered by Wipro at the end of the process training	*Assessed by Wipro* Integer from 0 to 100
	Mediating Variable	
Self Efficacy	Question on the survey administered at the end of process training, asking participants to indicate the extent to which they felt: (1) able to solve difficult problems if they tried hard enough; (2) capable of sticking to their aims and accomplishing their goals; (3) confident that they could deal efficiently with unexpected events; (4) able to find several solutions when confronted with a problem; and (5) able to handle whatever would have come their way.	*7-point scale, where 1 is strongly disagree and 7 is strongly agree* Five-item scale adapted from Schwarzer and Jerusalem (1995) (α=.78)
	Independent Variables	
Reflection	Intervention at the end of each day of process training (starting from day 6): "Please take the next 15 minutes to reflect on the training day you just completed. Please write about the main key lessons you learned as you were completing your training. Please reflect on and write about at least two key lessons. Please be as specific as possible."	*Manipulated* Dummy variable: 1 if reflection, 0 otherwise
Sharing	Intervention at the end of each day of process training (starting from day 6): "Please take the next 10 minutes to reflect on the training day you just completed. Please write about the main key lessons you learned as you were completing your training. Please reflect on and write about at least two key lessons. Please be as specific as possible. When done, you will be given another 5 minutes to explain these to another participant who is completing the training process with you."	*Manipulated* Dummy variable: 1 if sharing, 0 otherwise
Control	No intervention at the end of each day of process training	*Manipulated* Dummy variable: 1 if control, 0 otherwise
	Control Variables	
Age	Age of trainee in years	Integer count in years
Gender	Gender of trainee	Male = 1, Female = 0
Experience	Previous work experience (outside Wipro) of trainee in months	Integer count in months

Table 3. Descriptive statistics and correlations, Study 3.

Variable	Mean	Std. Dev.	1.	2.	3.	4.	5.	6.	7.	8.
1. Performance	66.097	16.193	1.000							
2. Reflection	0.389	0.489	0.269	1.000						
3. Sharing	0.299	0.459	0.208	-0.521	1.000					
4. Control	0.313	0.465	-0.488	-0.538	-0.440	1.000				
5. Age	25.201	3.613	-0.131	-0.096	-0.003	0.104	1.000			
6. Gender	0.833	0.374	-0.101	-0.217	0.170	0.060	0.030	1.000		
7. Experience	28.824	28.658	0.107	0.068	-0.042	-0.030	0.605	0.063	1.000	
8. Self Efficacy	6.242	0.481	0.272	0.151	-0.050	-0.109	-0.017	0.093	0.118	1.000

Table 4. Univariate Tests across Conditions: Reflection vs. Control, Study 3.

	Reflection (n=56)		Control (n=45)		T-test	
	Mean	S.D.	Mean	S.D.	t	Sig
Control Variables						
Age	24.768	0.483	25.787	0.560	1.385	0.169
Gender	0.752	0.060	0.872	0.049	1.769	0.080
Experience	31.245	4.483	26.930	4.053	-0.702	0.484
Mediating Variable						
Self Efficacy	6.332	0.048	6.166	0.082	-1.811	0.073
Dependent Variable						
Performance	71.536	1.308	54.422	3.088	-5.474	0.000

Table 5. Univariate Tests across Conditions: Sharing vs. Control, Study 3.

	Sharing (n=44)		Control (n=45)		T-test	
	Mean	S.D.	Mean	S.D.	t	Sig
Control Variables						
Age	25.341	0.512	25.787	0.560	0.586	0.559
Gender	0.932	0.038	0.872	0.049	-0.944	0.348
Experience	29.118	3.887	26.930	4.053	-0.389	0.698
Mediating Variable						
Self Efficacy	6.205	0.075	6.166	0.082	-0.346	0.730
Dependent Variable						
Performance	71.233	1.565	54.422	3.088	-4.789	0.000

Table 6. Univariate Tests across Conditions: Reflection vs. Sharing, Study 3.

	Reflection (n=56)		Sharing (n=44)		T-test	
	Mean	S.D.	Mean	S.D.	t	Sig
Control Variables						
Age	24.768	0.483	25.341	0.512	0.808	0.421
Gender	0.752	0.060	0.932	0.038	2.643	0.010
Experience	31.245	4.483	29.118	3.887	-0.347	0.729
Mediating Variable						
Self Efficacy	6.332	0.048	6.205	0.075	-1.482	0.142
Dependent Variable						
Performance	71.536	1.308	71.233	1.565	-0.150	0.881

Table 7. Results from OLS Regressions, Study 3. [a]

	Model 1		**Model 2**		**Model 3**	
	coef	**se**	**coef**	**se**	**coef**	**se**
Age	-1.392**	0.455	-1.024*	0.413	-0.925*	0.403
Gender	-4.795	3.509	-3.910	3.214	-5.017	3.147
Experience	0.171**	0.057	0.135**	0.052	0.116*	0.051
Reflection			15.076***	2.882	13.880***	2.831
Sharing			16.549***	2.987	16.373***	2.905
Self Efficacy					7.256**	2.425
_cons	100.259***	11.033	80.459***	10.505	34.687†	18.392
N	144		144		144	
F	4.296		10.985		11.175	
Adjusted R2	0.065		0.259		0.299	

[a] *** p<0.001, ** p<0.01, * p<0.05, †<0.01

Figure 1. An example of the type of grid participants were asked to solve, Study 1.

8.18	9.01	3.97
5.2	4.56	9.12
0.28	2.92	6.59
1.12	6.93	9.72

Figure 2. Performance across conditions before and after the manipulation took place, Study 2.