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Acquisition of Machinist Expertise Through Self-Directed Learning

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Abstract

The current study examined the value of employee self-directed learning (SDL) activities to acquire job knowledge in preparation for upskilled jobs in a unionized manufacturing plant. Prior to the study, the culture of this plant had not encouraged or rewarded individual initiative to learn and use new skills. During the study, management encouraged SDL efforts among employees, but did not require SDL or allow work time to be used for SDL. A path model was employed to test relationships between job performance, cognitive ability, SDL, and two potential predictors of SDL: self-efficacy and conscientiousness. Results indicated that the number of SDL activities employees engaged in was a significant predictor of job knowledge, independent of cognitive ability. Additionally, self-efficacy was a significant predictor of SDL, but conscientiousness was not. Factor analysis results suggested that the learning activities employees engaged in fell into three categories: self-directed, traditional, and unstructured. Only the self-directed category has a significant positive correlation with job knowledge. Implications for organizations and employees regarding the acquisition of expertise through SDL are discussed.

Acquisition of Machinist Expertise Through Self-Directed Learning

Many writers have addressed the numerous trends that are changing the workplace, such as technological innovation, globalization, worker empowerment, growth of the service sector, and changes in workforce demographics (e.g., Judy & D'Amico, 1997; Howard, 1995). The primary implication posed by this constellation of workplace influences is that the amount and complexity of job knowledge needed by workers is growing exponentially, while overall workforce skills are declining. Therefore, the success of organizations and their workers will increasingly be contingent on the capacity and effectiveness of their learning (e.g., Carnevale, 1995; Gugliemino, 2006; Senge, 1990).

These unprecedented increases in job knowledge demands have led to a growing concern among both researchers and practitioners in the issue of continuous updating of job knowledge (Dubin, 1990; Kozlowski & Farr, 1988; Noe & Ford, 1992; Noe & Wilk, 1993; Rosow & Zager, 1988; Tannenbaum, 1997; Zemke, 1998). The goal of continuous updating is development of expertise through acquisition of breadth and depth in job knowledge. Organizations continue to provide a wealth of formal and informal training to meet these needs. However, the amount of learning required simply overwhelms the capacity of the traditional organizationally controlled systems of learning, and the resources to provide it. As reported in a 1999 survey conducted by the Nierenberg Group "86% of employees see self-improvement as important to success" yet only "72% reported they get enough training from their company." (Shah, et al, 2001). Organizations and their employees must seek increasingly efficient ways to meet their ever-expanding learning demands.

One approach to addressing these knowledge demands is self-directed learning (SDL). The primary responsibility for learning has always been, and will continue to be, with the learner. Organizations continue to provide both formal and informal training, as well as incentives to learn. However, even in formal training settings the amount of learning that occurs fundamentally depends

upon the learner (Gugliemino, 2006; Noe, 1986; Noe & Schmitt, 1986). We propose that trends in the changing workplace will underscore the importance of self-direction in learning. For example, Ellinger (2004) states that "flexible training, delivery, and SDL approaches have emerged as organizational responses to meet the complex demands associated with the changing world of work." Workers have more access to information, as well as a greater need for information, than ever before. Increasingly, worker self-direction will determine the extent to which they make use of this information, and how this impacts their job performance.

Job Knowledge, Learning, and Job Performance

Job knowledge plays a fundamental role in models that predict job performance (Borman, W. C., White, L. A., Pulakos, E. D. & Oppler, S. H., 1991; Hunter, J. E., 1983; Schmidt, F. L., Hunter, J. E., & Outerbridge, A. N., 1986). These models have demonstrated some very stable relationships among cognitive ability, job knowledge and job performance. Specifically, cognitive ability predicts job performance through a direct path, as well as an indirect path through job knowledge. These studies have consistently concluded that the largest path coefficient in the performance models has been the path from job knowledge to performance. This highlights the central importance of job knowledge to job performance.

Additionally, these models have concluded that both cognitive ability and job experience are significant contributors to job knowledge. However, the growing importance of continuous updating of job knowledge suggests that a third contributor to job knowledge is important: ongoing learning activity. This learning can include a variety of learning experiences, from formal training to informal learning. Informal learning has been given a variety of names, including just in time learning, incidental learning, open learning, adult learning, lifelong learning, and autonomous learning. In all cases, this learning is to some extent self-directed. The presence and importance of self-direction in the acquisition of job knowledge is central to this study.

Self-Directed Learning

One of the most commonly cited definitions of SDL, and the one most salient to workplace job knowledge and training research, was offered by Knowles in 1975:

> "In its broadest meaning, 'self-directed learning' describes a process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes."

Several points in this definition of SDL are worth emphasizing. First, SDL is learning for which individuals take the initiative. Individuals can be motivated to do so, but they are not required to do so. Second, SDL does not require learning in isolation; SDL can be facilitated in a number of ways. Finally, SDL involves a number of steps associated with the process of sound formal training design (e.g., Campbell, 1988).

Using this definition of SDL, it is apparent that SDL is something that people use widely to accomplish the learning necessary to simply get through the many challenges they encounter in their lives. For example, people learn how to buy homes, build decks, raise children, etc. Studies have demonstrated that individuals in many walks of life undertake a number of learning projects each year that are essentially self-directed (e.g., Houle, 1961; Spear & Mocker, 1984; Tough, 1967, 1979). Some of these projects are related to acquisition of job knowledge, and others are related to personal interests.

Because SDL is ubiquitous among adults, both within and outside of the workplace, it would be reasonable to conclude that most adults have developed, at least to some extent, requisite learning skills. When sufficiently motivated, most adults do identify what needs to be learned and find some means to acquire the knowledge they need. However, this learning is not always efficient or effective. Spear and Mocker (1984) reported that many adult learning projects are not consciously planned, but emerge out of the "organizing circumstance". That is, people use the ideas and resources available in their immediate environment to structure their learning experiences. As might be expected, such an expedient process often falls short of what a carefully planned process could achieve.

SDL and Job Knowledge Acquisition

We have very little systematic knowledge about the application of SDL to acquisition of job expertise. Yet, because the need for self-direction in learning in the workplace will continue to grow, there exists a compelling practical need to understand it. Individuals naturally undertake SDL. However, without a systematic understanding of SDL, organizations have little to guide them in structuring systems to facilitate and channel SDL in ways that are consistent with organizational goal accomplishment.

SDL has been virtually ignored in the I/O psychology literature, which has focused primarily on formal training for both initial acquisition and updating of job knowledge (e.g., Goldstein, 1991; Kozlowski & Farr, 1988; Noe & Wilk, 1993). The few exceptions to this reflect recent organizational efforts to incorporate SDL into organizationally sponsored training activities (e.g., Piskurich, 1994; Guglielmino & Murdick, 1997). A related study by Warr & Bunce (1995) reported that junior managers were successful in acquiring job knowledge through an 'open learning' management development program, and that their learning had a significant impact on performance. There is an absence of research that explicates relationships between SDL and other performance-related constructs.

However, the role of SDL has been directly addressed in the education literature that focuses on continuous updating among professionals (e.g., Ash, 1985; Confessore & Confessore, 1994; Jennet, Jones, Mast, Egan & Hotvedt, 1994; Kops, 1997). This research reflects that self-directed learning (SDL) is a very important source of ongoing knowledge acquisition. Professionals, because of their need to keep up with evolving knowledge, have a well established tradition of lifelong learning, much of it self-directed, to acquire and maintain expertise (Houle, 1980; Schein, 1972). For example, Jennett et al. (1994) identified three distinct forms of SDL that have long been used by physicians: informal, ongoing, habitual activities directed to the maintenance of competence; semi-structured learning experiences that typically have their basis in immediate patient problems; and formal, intentional,

planned activities. These forms of learning are certainly generalizeable to most occupations. The first two forms involve a good deal of reading professional literature and informal discussions with colleagues. Rothwell & Kazanas (1990) have also identified these as common modes of learning in the workplace.

We suggest that SDL is important to most, if not all, jobs. It is common for a wide range of workers to undertake a variety of activities through which they acquire job knowledge. For example, workers seek information from more expert workers in order to solve problems or do work more efficiently, they read materials beyond what is required to do the basics for the job, and they talk to workers in related professions to expand the breadth of their job knowledge. As work technology becomes increasingly complex, workers naturally utilize SDL to complement the less-than-adequate formal training they often receive (Shah et al, 2001; Straka, Klienmann & Stokl, 1994).

SDL is a logical extension of worker empowerment. Implementation of worker empowerment has expanded greatly and proven to be highly effective in the workplace when employees are provided with requisite knowledge (Randolph, 1995; Straka, 2002). Just as workers can assume responsibility for making process improvements regarding workflow, they can also assume responsibility for participation in decisions regarding many aspects of the process of training design. For example, with proper preparation, a wide range of employees might be able to participate in decisions regarding what needs to be learned and how learning should proceed.

With the growth of opportunity and need for SDL in the workplace, it would be useful to identify individual differences that meaningfully distinguish which employees choose to engage in SDL. Because existing research does not address this specifically, we use related research to build a case for potential predictors of SDL.

Predictors of Self-Directed Learning

Choices regarding whether to expend effort, what level of effort to expend, and the persistence of effort are the three basic components of motivation (Campbell & Pritchard, 1976). Previous

research suggests that two constructs might be important predictors of SDL-related motivational choices: self-efficacy and conscientiousness.

Self-Efficacy. Self-efficacy reflects an individual's judgments about how well he/she can execute actions required by prospective situations (Bandura, 1982). These judgments influence action-related thought patterns and choices (Bandura, 1997). Jones (1994) and Candy (1991) suggest that SDL-related self-efficacy is an important precursor to SDL, and that lack of SDL-related self-efficacy can impede SDL. In addition to Jones and Candy, it has been reported that self-efficacy for learning and development has key relationships with employee attitudes, intentions and voluntary participation in development activities (e.g. Maurer & Palmer, 1999). Manz and Manz (1991) proposed a model for the facilitation of SDL, which focused primarily on importance of self-efficacy. Similarly, Noe and Wilk (1993) specified self-efficacy as an antecedent in their conceptual model of employee development activity. Their empirical results demonstrated that self-efficacy was a significant predictor of self-report measures of development activity in all three of their samples. Further work by Wilk & Noe (1997/1998) reported that self-efficacy was a significant predictor of motivation to learn.

These researchers draw upon research by Bandura and colleagues (e.g., Bandura, 1982; Bandura & Cervone, 1986; Bandura & Schunk, 1981; Wood & Bandura, 1989), which indicates that self-efficacy plays an influential role in the motivational choices individuals make. Together, this body of work suggests that individuals who have high self-efficacy about their ability to cope with a job that requires ongoing learning are more likely to pursue and assume responsibility for work-related SDL than those low in self-efficacy. These individuals should have less hesitation to undertake a variety of knowledge acquisition activities, and have increased probability of success in learning.

Further, Locke, Frederick, Lee, & Bobko (1984) demonstrated linkages between self-efficacy and goal setting. Their research demonstrated that perceived self-efficacy impacts the self-set goal level, goal commitment strength, and level of cognitive performance. Similarly, Bandura and Cervone (1986) found support for the assertion that the combination of high self-standards (goals) and self-

belief in one's capability to realize them (self-efficacy) can create challenges that spur motivation. That is, when self-efficacy gets a boost, it helps build interest and leads to sustained involvement in challenging activities (Bandura & Schunk, 1981).

Conscientiousness. The literature on the usefulness of personality in the prediction of job performance has grown significantly in the past few years (Borman, Hanson, & Hedge, 1997). One consistent finding is that the construct of conscientiousness is a significant predictor of performance across a wide range of jobs (Barrick & Mount, 1991; DeNeve & Cooper, 1998; Rust, 1999; Tett, Jackson, & Rothstein, 1991). Conscientiousness reflects dependability and the will to achieve (Barrick & Mount, 1995). The meta-analytic results support the notion that the conscientious employee will generally attempt to accomplish the full range of job tasks in a manner that is expected by the organization, which results in a high level of job performance. Employers rely on conscientious employees who choose to do what it takes to get their job done.

Similarly, one might expect that conscientious employees would respond well to the learning challenges inherent in their jobs. That is, such employees would choose to take the initiative to learn what is required to accomplish job tasks satisfactorily because conscientiousness increases as a result of having learned to competently function in jobs (Hoare, 2006). For example, if an employee lacks knowledge that is necessary for competent task accomplishment, high conscientiousness would spur the employee to seek this knowledge, irrespective of whether the employer provides the requisite training. Therefore, it is likely that conscientiousness could give rise to the choice to expend effort on learning, to undertake SDL activity.

The Current Study

The current study attempts to initiate a stream of empirical SDL research in the I/O psychology literature with two specific goals. The first is to examine linkages between SDL, job knowledge, and job performance. We do this by integrating SDL with elements of existing performance and continuous updating models. The second is to demonstrate that the domain of interest in SDL and continuous

updating should be extended beyond professional jobs, and thereby suggest that it is potentially salient to most, if not all jobs. The current study employs a subject population largely ignored in the research literature: blue collar workers. This population is of great interest for four reasons. First, educational attainment among these employees is primarily high school level. They have generally had formal learning experiences that were more limited in number, and often in success, than white-collar workers. Second, these workers usually receive much less ongoing training from their employers than do managers and professionals (Carnevale, Gainer, & Villet, 1990). Third, unlike professionals, blue-collar workers lack a tradition of incentives and expectations that inspire their use of SDL for acquisition of job expertise. Finally, blue-collar workers face dramatic increases in job-related learning requirements in the years ahead (e.g., Carnevale, 1995), and "the success of the new manufacturing initiatives depends on harnessing and developing shopfloor expertise" (Wall & Jackson, 1995, p. 157).

The study examines four hypotheses. Hypothesis one reflects results from past research that has modeled the prediction of job performance. We propose that cognitive ability will have a significant relationship with job performance, both through a direct path and an indirect path through job knowledge. Hypothesis two suggests that learning activity, in addition to cognitive ability, will have a significant relationship with job knowledge. We propose that SDL activity will be significantly correlated with job knowledge, independent of cognitive ability. Hypotheses three and four draw upon previous research which suggests two factors that impact motivational choices could have significant relationships with SDL. We propose that self-efficacy and conscientiousness will be significant predictors of SDL. Finally, we take an exploratory look at the relative frequency with which the various types of SDL activities were used by employees, and examine their relationships with job knowledge and job performance.

Methodology

Research Setting

The study took place in a manufacturing plant in the Midwest with a strong union. Because the

organization offered very little training to workers, they were accustomed to learning “on-the-job”. Subsequently, some self-direction in learning had most likely been present among workers. However, the union had a long-entrenched seniority system that determined how jobs were filled in the plant, and there was a glaring absence of incentives or recognition from the organization to promote use of SDL by workers for the acquisition of job expertise.

This plant, like many others, was faced with the need to shift from a conventional manufacturing process to a state-of-the-art manufacturing process that utilized computer numerically controlled (CNC) machine tools. The organizational situation was hardly conducive to the required empowerment inherent in this change process, much less the knowledge acquisition process required to support the change.

Management succeeded in obtaining an exemption to the union’s seniority system in filling the upskilled, higher paying jobs. Management’s challenge was then to determine who had the knowledge and the initiative to succeed in the first set of upskilled jobs that would be made available to the employees as the plant transitioned to the new processes. These jobs would require a much higher level of technical expertise than had been required in the current manufacturing processes. Additionally, employees would apply their expertise to do troubleshooting and problem solving on their own while working with the CNC machines.

Management informed employees of the pending changes and used a multi-step process to involve them in preparation for the jobs. Management-union relations were quite hostile, and the union was very skeptical of this change process. In fact, workers suspected that management was attempting to take advantage of them, and they voiced concerns about being treated as “guinea pigs”. However, after much negotiation, management and the union did agree to the following three-step process: a practice test, an individual feedback session, and a qualifying test.

Practice test. Step 1 was offered to all employees but not required of any employees. The union had requested the administration of the practice test for two reasons. First, most employees had

little recent experience with paper and pencil tests. The practice test would offer an opportunity for exposure to testing, which could alleviate some anxiety among employees. Second, and more important, the practice test would provide employees with an opportunity to preview the content domain of the qualifying test. Scores on the practice test would provide valuable information for employees regarding the adequacy of their current job knowledge, and help identify for them what areas they would need to acquire more knowledge.

Individual feedback session. Step two was offered to all employees who took the practice test, but was not required of any employee. An executive in the plant conducted each individual feedback session. The executive reviewed the practice test results with the employee, and discussed identified which questions the employee had answered correctly and incorrectly. A critical aspect of this feedback session was discussing what the employee could do to prepare for the qualifying test. It was made clear that the organization would not provide assistance in this preparation, and that each individual was expected to devise and undertake his own self-directed learning plan. Employees were encouraged to learn as much as they could, because only those employees who passed the qualifying test would be given the opportunity to attend formal training in how to use the new CNC machinery, and the subsequent jobs that utilized it.

A number of learning options were discussed: finding and taking a course with related content (some courses were suggested by management), reading, studying content areas associated with incorrect answers on the practice test, joining an informal study group, talking to others who had taken the practice test (outside of a study group), and asking questions of coworkers (outside of a study group). Even though some options involved other employees, all study efforts were to be held outside of working hours. Study groups were organized by the employees and did not involve management in any way. Employees who did not take the practice test did not have an opportunity to see the practice test, and they were informed about the SDL options through bulletin board postings. Employees had a period of 8 weeks between the practice test and the qualifying test to increase their job knowledge.

Qualifying test. Step three was also offered to all employees, but not required of any employees. The qualifying test of job knowledge covered the same content domain as the practice test. Employees who took the qualifying test were also given additional measures, including cognitive ability, personality, and self-efficacy.

It is important to reiterate here that the organization clearly and consistently informed employees that self-direction was expected of those employees who chose to obtain the upskilled jobs. Employees were told that the CNC jobs required a higher level of knowledge than the current jobs, and that the organization would restrict formal training for these new jobs to those workers who took the initiative to acquire the appropriate baseline knowledge. SDL was built into the 3-step process of obtaining the upskilled jobs, and was expected on an ongoing basis of those employees who filled these jobs. These SDL expectations were a radical departure from prior expectations in the conventional process plant, as was the incentive of more secure and higher-paying jobs.

Subjects

All subjects were skilled machinists employed by the manufacturing plant. All were white males. The employees who took the qualifying test were administered a variety of measures for the current study in addition to the test. Of the 80 employees who were potentially qualified for the new jobs, 64 took the qualifying test. Complete data on all measures included in the study were obtained from 58 employees. Additional demographic data (experience, education, etc.) on the subjects were not available because the union disallowed access to this information.

Measures

Job performance. The job performance score was a quantitative index of typical performance (Sackett, Zedeck & Fogli, 1988). Daily individual performance data were gathered for the 6-month period prior to the practice test by an automated data collection system. Engineered standards were available for all work tasks. The performance score represents the average efficiency against engineered standards for all work tasks performed by each subject over the period of 6 months.

Job knowledge. A technical skills test for precision machinists was used to measure job knowledge (the qualifying test described above). This test was developed by the National Occupational Competency Testing Institute (NOCTI) and is distributed by Wonderlic (1997). The total number of items in the NOCTI test was 200. Four managers rated the relevance of all items for this job setting. The results of these ratings led to the selection of 120 items, which comprised the qualifying test. Reliability for the 120 item test was not possible to compute because we did not have access to item-level data. However, reliability for the 200 item test reported by Wonderlic (1997) is .94 (KR-21).

Cognitive ability. The 50 item Wonderlic Personnel Test (WPT; 1992) was used to assess cognitive ability, and was administered at the qualifying test session. Again, reliability for the current sample was not possible to compute because we lacked item-level data, but Wonderlic reports an internal consistency reliability of .88 for the WPT (1992).

SDL. SDL was represented by the total number of SDL activities undertaken by each employee in preparation for the qualifying test (that is, during the 12 week period between the announcement of the qualifying process and administration of the qualifying test). Subjects were asked to indicate what they did to prepare for the qualifying test, and could check which of 8 SDL options they pursued (taking the practice test, the 6 SDL options discussed during the individual feedback session after the practice test, and 'other'). The range of scores was 0 to 7.

Self-efficacy. A 5-item scale was used to assess self-efficacy. Subjects were asked to indicate their level of confidence in operating in the new computerized work environment, which included learning what was needed to do the job. Items ranged from doing this with step by step guidance from others to doing this without any guidance from others. Response options included "not at all confident" (1) to "completely confident" (5). Coefficient alpha for the scale was .86.

Conscientiousness. The Personal Characteristics Inventory (Barrick & Mount, 1995, distributed by Wonderlic) was used to measure conscientiousness. Response options for each item ranged from 1 (disagree) to 3 (agree). Coefficient alpha for the conscientiousness scale for this sample was .67 (test

publishers report an average alpha of .87 for the conscientiousness scale).

Analyses and Results

Path analysis (AMOS, v. 3.6, Arbuckle, 1997) was employed to test the hypotheses. Means, standard deviations, and intercorrelations for all variables are displayed in Table 1. The path model and results are displayed in Figure 1.

Path coefficients in Figure 1 indicate support for Hypotheses 1, 2, and 3, but not for Hypothesis 4. Path coefficients from both cognitive ability (.24) and job knowledge (.58) to performance are significant ($p < .05$; critical ratios = .2.1 and 5.0, respectively). Path coefficients from both cognitive ability (.66) and SDL (.22) to job knowledge are significant ($p < .05$; critical ratios = 7.0 and 2.3, respectively). The path coefficient from self-efficacy (.28) to SDL is significant ($p < .05$; critical ratio = 2.1). Finally, the path coefficient from conscientiousness to SDL (.07) is not significant ($p > .05$; critical ratio = .5).

Goodness of fit indices indicate a reasonably good fit of the model (df = 6; $X^2 = .59$; NFI = .99, ECVI = .87, RMSEA = .07). Browne & Cudeck (1993) suggested that an RMSEA of .08 or less indicates a reasonable error of approximation. Squared multiple correlations in the model indicate that a much greater percentage of variance was explained for the prediction of job performance (.59) and job knowledge (.50) than prediction of SDL activity (.10).

Means, standard deviations, and correlations among the various SDL activities appear in Table 2. The most frequently used SDL activities were taking the practice test (57%) and studying areas identified by the practice test (55%), reading (47%), and asking others for help (47%). Talking to others who had taken the practice test (outside of a study group) was also used frequently (40%). However, less than one third of subjects joined a study group (31%), and even fewer took a class (21%). Only 12% of subjects indicated they did some ‘other’ SDL activity.

Principal components analysis with varimax rotation was used to assess the factor structure of the SDL activity options. The SDL option of “other” was not included in the factor analysis because

none of the subjects who selected that option filled in the blank to indicate what they had done. Three factors had eigen values greater than 1, and together accounted for 66% of the variance. The factors and their loadings appear in Table 3. Factor 1 accounted for 26% of the variance, and was comprised of studying areas identified by the practice test, asking for help from coworkers (but not in a study group), and taking the practice test. Factor 2 accounted for 23% of the variance, and included taking a class, joining a study group, and reading books. Factor 3 accounted for 17 % of the variance and included talking to others who took the practice test (outside of a study group). Although the ratio of subjects to variables included in the factor analysis was perhaps inadequate, the resultant loadings were clean and readily interpretable.

Table 4 presents correlations of the factor scores with job knowledge and job performance. The correlation of factor 1 with job knowledge was significant and positive (.25, $p<.05$). Factor 2 was not significantly correlated with either job knowledge or job performance. The correlation of factor 3 with job performance was significant and negative (-.25, $p<.05$). Further examination of the data revealed that the majority of subjects (16 of 27) who had a positive factor score for factor 3 (talking to others who took the practice test, outside of a study group) had not taken the practice test. Also, these subjects had a significantly lower mean cognitive ability score (20.2) than those with negative scores for factor 3 (23.4; $t = -2.0$, $p<.05$), and they had undertaken significantly more SDL activities (4.0) than did those with negative scores for factor 3 (2.6; $t = 3.3$, $p < .01$). However, self-efficacy and conscientiousness scores were not significantly different between these groups.

Discussion

SDL is recognized as commonplace among professionals, who usually have a wealth of formal learning experiences through which learning skills are acquired. The current study provides some evidence that SDL can be effective in the blue-collar sector, as well, among employees who have had fewer formal learning experiences and likely have lower levels of learning skills.

Two particularly encouraging findings emerge from this study. First, blue-collar employees were willing to undertake a variety of SDL initiatives to extend their level of expertise in preparation for upskilled jobs, despite the lack of congruence this behavior shared with the previous work climate and norms. This is significant because employers are increasingly implementing updated technology that requires employees to acquire additional job knowledge. As training budgets grow ever tighter in organizations, our results suggest that employers could utilize SDL to extend formal training efforts. The organization was very pleased with the fact that 60% of employees who took the qualifying test had passing scores, which was a considerable increase over the 21% pass rate for employees who took the practice test. The self-directed preparation period had produced ample employees who were prepared to start CNC machine training.

Second, the employees who engaged in a greater number of SDL activities had higher levels of job knowledge than those who engaged in fewer SDL activities. Independent of cognitive ability level, the number of SDL activities employees undertook in preparation for the qualifying test had a significant relationship with job knowledge. This suggests that employees are capable of doing effective learning on their own, across a range of cognitive ability levels. The zero correlation between cognitive ability and SDL activity (-.01) provides further support that SDL activity is not simply a proxy for cognitive ability; it's not just a reflection of ability to learn.

Campbell's (1990) model of job performance proposes that there are three determinants of job performance components: declarative knowledge, procedural knowledge and skill, and motivation. Results of this study demonstrated that job knowledge was, indeed, a major determinant of job performance. This model suggests that SDL activity, as represented in this study as the number of SDL activities undertaken, might be a proxy for motivation. Specifically, it is perhaps a behavioral sample, rather than a sign, of motivation (Wernimont & Campbell, 1968). The number of SDL activities engaged in by employees does reflect motivation in a specific direction. However, we call attention to the importance of identifying individual differences associated with the choice to undertake SDL.

The finding that conscientiousness was not a significant predictor of SDL activity was somewhat surprising. Perhaps the high mean (2.7 out of 3) and small standard deviation (.2) for this variable limited its predictive capacity. Another possibility is that conscientiousness is a broader personality construct that reflects both dependability and will to achieve (Barrick & Mount, 1995). It would seem that the more salient of these two characteristics to the motivational choices involved in choosing to undertake any number of SDL activities might be the will to achieve. This approach is consistent with Hough (1992), who suggested that examination of personality traits at a more fine-grained level than the 'big five' can provide better prediction of performance-related criteria.

That self-efficacy was a significant predictor of SDL activity is congruent with results of previous research. Additionally, because self-efficacy is an important antecedent of goals (e.g., Locke, et al., 1984; Straka, 2002), it is possible that goal-related constructs, such as goal difficulty, goal conflict, and goal commitment, might be of central importance to the prediction and facilitation of SDL.

The motivating impact of the job situation in the current study was admittedly high, which no doubt contributed to the fact that so many employees undertook SDL activities voluntarily. Employees knew that the upskilled jobs were their ticket to higher pay and greater job security. However, this high level of motivation should be common across many situations where jobs are changing due to technological advances. Even if higher pay is not offered in a job upskilling situation, experience with technological change over the past decade has made most employees well aware that their employability is threatened when their job skills become obsolete.

The factor structure of the SDL activities revealed 3 very different approaches to learning. The learning activities comprising factor 1 reflect the most self-directed style of learning (studying weak content areas identified by the practice test, independently asking coworkers for help, and taking the practice test). Those in factor 2 reflect the more traditional modes of learning (taking a class, reading,

and joining a study group). The learning activity in factor 3 (talking to others who took the practice test) reflects a very unstructured approach to learning.

That the most self-directed style of learning was significantly correlated with job knowledge is very encouraging. Further, that it was they only style that was significantly correlated with job knowledge is interesting. Speculation about the reason for this suggests several possibilities. First, this finding could be attributable to the content domain studied; perhaps those who took a class and read covered a broader content domain, whereas those who concentrated their efforts around the practice test covered a better focused content domain. Alternatively, it could be attributable to differences in learning and study skills between subjects who employed different strategies. Finally, it could be related to the fact that those who didn't take the practice test did not have an individual meeting with the company executive, which could have influenced their understanding of personal job knowledge deficiencies and SDL options, or their motivation. Unfortunately, our data cannot provide insight into which of these possibilities had a meaningful impact on differences in job knowledge acquisition.

The finding that the unstructured style of learning had a significant and negative correlation with job performance is also informative. As noted earlier, the majority of the subjects who employed this style did not take the practice test, and they tended to have lower cognitive ability and attempt a broader array of SDL activity. Perhaps these individuals have a more difficult time identifying and working toward desired workplace goals, in general. If so, this group of subjects might benefit most from organizational facilitation of SDL to help them initiate their learning process and provide guidance and encouragement along the way.

Limitations and Future Research

One possible limitation of this study is that our SDL measures represented the quantity of SDL activity and not the quality of this SDL activity. This approach is consistent with previous research, which has used the number of learning projects engaged in during a given amount of time, or total hours spent (e.g., Houle, 1961; Spear & Mocker, 1984; Tough, 1967; 1979). The questionnaire did ask

employees to indicate the total number of hours they spent on SDL activities, but we did not feel that this was a reliable measure because a number of subjects wrote that they didn't keep track of hours spent and that it was too difficult to estimate accurately. One approach to measuring quality of learning might have been to use ANCOVA to examine differences between practice test and qualification test scores (Arvey & Cole, 1988). Unfortunately we could not employ this approach because we did not have access to a control group.

Therefore, these data cannot inform us whether engaging in a greater number of SDL activities was associated with superior knowledge acquisition during the 8-12 week period of SDL between announcement of the 3-step qualifying process and the qualifying test. It is possible that subjects who engaged in more SDL activities during this time are simply those individuals who are predisposed to doing ongoing SDL, and therefore have had more opportunities to acquire job knowledge than subjects who engaged in fewer SDL activities. Alternatively, it could be that engaging in a broader array of learning activities could contribute meaningfully to the process of acquiring expertise. Future research is needed to sort out these relationships.

The framing and results of this study suggest that SDL-related research has the potential to meaningfully address the mounting learning challenges faced by organizations and their workers. The absence of SDL-related theory is the most glaring research need. Currently there is insufficient explication of the role of SDL in work-related learning and its subsequent role in job performance, as well as limited knowledge upon which to base sound practice that supports SDL within organizations.

Additionally, SDL theory development should address both the predictor and criterion sides of SDL. For example, as demonstrated in this study, SDL can serve as a predictor of job knowledge. However, it can also serve as a criterion, reflective of the performance dimension of skill development. In addition to the 8 performance dimensions that apply to all jobs, as suggested by Campbell (1990), DuBois, Shalin, Levi & Borman (1997/1998) propose that skill development is an additional performance dimensions, or task domains, that apply to all jobs. This dual role is similar to that of

effort, which Campbell (1990) identifies as both an antecedent of performance and a dimension of performance that is common across jobs.

Development of an SDL criterion measure would require identification of what kinds of SDL are required at work, and delineate both implicit and explicit learning goals. DuBois, DuBois, & Epstein (1998) developed a goal framework for SDL that distinguished goals along two lines: simple/complex and proximal/distal. They identified "embedded SDL" as those learning goals that fall into the complex and proximal quadrant, those learning goals that are implicit and embedded within task goals. The nature of embedded learning goals is such that they are rarely addressed in formal training, but such learning could contribute very meaningfully to job performance. Research is needed to tease out both SDL and embedded SDL within performance and develop sound measures of them.

Development of criterion measures should be followed by additional work to identify and develop predictors of SDL. Drawing from Campbell's (1990) model of performance, we can expect that these predictors will be either related to knowledge, skill, or motivation. The current study investigated two constructs that are related to motivation: self-efficacy and conscientiousness. However, path model fit statistics would have improved if a greater percentage of variance in SDL activity had been explained by these two constructs. Additional motivation-related constructs that might be useful predictors of SDL include more fine-grained personality characteristics (such as achievement and potency), goals (e.g., Locke et al., 1984), performance - mastery orientation (Dweck, 1986), action - state orientation (Kuhl, 1992), and attitude toward SDL. The SDLRS (Guglielmino, 1978), which assesses primarily attitudes toward SDL, was developed to assess SDL readiness. The SDLRS has been used in a number of studies by education researchers (see Guglielmino, 1997). However, it's usefulness in assessing readiness for work-related SDL is limited because items tap the broad usage of SDL in any area of life. Perhaps the development of a similar measure that is tailored to work-related SDL would be useful.

Further, Campbell (1991) suggested that predictors of SDL extend beyond those associated with

motivation. Specifically, he proposed that knowledge and skill of training design are important antecedents of SDL. Knowles (1975) proposed an SDL skill set that includes many of the basic steps of training design (e.g., Campbell, 1988). There are no reports, however, of the efficacy of these steps in developing SDL expertise. Additionally, there are no instruments that purport to assess a learner's SDL skill set. Development of such an instrument would also be useful.

Another area that merits future research is identification of the relative effectiveness of different approaches to SDL and reasons why individuals choose different approaches in their pursuit of SDL. These insights could provide useful guidance to organizations that choose to facilitate and reward SDL among their employees. Some SDL activity choices might better target the content domain to be mastered than other choices. Also, the various SDL activity choices might require different kinds of facilitation from the organization. Finally, some individuals might be successful in their SDL because they make choices that are consistent with their learning skill set, whereas others might not meet with success because their SDL activity choices are incongruent with this skill set.

A final research suggestion is to explore the role of SDL in job experience, as related to knowledge acquisition. Schmidt, et al. (1986) noted that "Job experience appears to lead to increased job knowledge by providing work opportunities for knowledge acquisition. Ability leads to increased job knowledge by speeding up the process of acquisition." (p. 436). We propose that these work opportunities for knowledge acquisition involve much SDL, particularly embedded SDL. For example, Straka, et al. (1994) note that employees often undertake SDL because they need to learn things to get their jobs done and their employers don't provide formal training. The recent model of work experience by Tesluk & Jacobs (1998) fails to directly account for the role of learning activities that are not part of task activities but are necessary for task accomplishment, which employees undertake voluntarily. Most of such learning would be classified as SDL, or embedded SDL (DuBois et al., 1998). Further research is necessary to tease out these relationships more specifically.

Implications for Organizations

Organizations will increasingly be dependent upon and concerned with the development of employee expertise as we move into the next century. Because the cost of keeping employee skills up to date through formal training efforts is prohibitively high, organizations must seek additional means to accomplish this important goal. SDL is a promising means for organizations to employ. Whereas SDL has a well-established history among professionals, the current study suggests that SDL can successfully be utilized in the blue-collar workforce, as well.

We propose that as SDL research progresses and as SDL becomes increasingly recognized and facilitated by organizations, the implications of individual SDL capabilities will extend beyond the realm of training and development. Consideration of SDL capabilities will become relevant in employee selection, and will have implications for a range of performance management issues. In essence, we believe there is an exciting future for SDL-related research and practice that will be driven by the needs of the workplace.

Motorola is currently pioneering efforts to integrate SDL into their extensive training efforts (Guglielmino & Murdick, 1997). The training department plays an essential role in facilitating SDL among employees. For example, employees work with trainers in their training department to acquire basic training design and learning skills to support SDL. They work together to develop SDL plans, such as learning contracts, to design and monitor SDL programs, and to evaluate results. Trainers offer support and guidance as workers pursue SDL. This approach builds a positive organizational climate for SDL. Additionally, such a facilitated process provides opportunities for all employees to acquire, at their own pace, the basic skills to help them succeed in SDL.

The challenges to implementing SDL in the workplace are great. Resistance can come from employees as well as from corporate trainers. Blackwood (1994) notes that employees often flounder in their initial forays into acquisition of work-related knowledge through SDL. Trainees are accustomed to being ‘spoon fed’ in formal training settings, and they are uncomfortable with playing a

more active role in seeking knowledge and evaluating their learning. Similarly, implementation of SDL challenges trainers' willingness to share control of the learning process with trainees (Phelan, 1996). Trainers are accustomed to directing trainee learning processes, and they are uncertain that trainees can successfully acquire knowledge through SDL. Furthermore, they fear that extensive use of SDL can challenge the perception of the extent to which they are needed within the organization. For example, if employees can learn on their own, why maintain a training staff?

However, experience at Motorola demonstrates that the training staff is a key component to the success of SDL implementation (Guglielmino & Murdick, 1997). They are part of the myriad resources required to successfully implement SDL within an organization. We propose that training staff can play a critical role in working with employees and their superiors to make explicit the learning goals associated with, and often embedded within, job task accomplishment. At Motorola, both trainers and a wealth of learning resources are made available to workers. This process is not without costs, but it has proven to be less expensive in the short-term than formal training, and the long term costs are expected to decrease as workers become more self-sufficient at learning (Guglielmino & Murdick, 1997).

Further, Candy (1991) and Kops (1997) have suggested additional key components necessary to establish a context for SDL in the workplace, those targeted at larger organizational issues. These include the establishment of an organizational climate that promotes self-direction and inquiry, and articulation of clear organizational direction for employees in order to provide a foundation for alignment of SDL with the mission and goals of the organization. Along with Guglielmino and Guglielmino (1994), they also emphasizes the importance of resource support, which includes provision of expert training staff, establishment of learning resource centers with a host of materials for use in SDL, and provision of external opportunities to employ SDL such as access to conferences.

In closing, we wish to reiterate that, although the organizational support efforts for SDL were limited in the current study, employees still rose to the SDL challenge placed before them and

accomplished a great deal in a short time. The available incentives spurred employees to choose to perform at a high level of effort during this eight-week period. As noted by Bandura and Cervone (1986), "…motivation through aspiration provides an important and continuing source of self-efficacy, interest, and personal satisfaction…Life without elements of challenge can be rather dull" (p. 111).

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Table 1

Means, Standard Deviations, and Intercorrelations for Path AnalysisVariables

Variables	Mean	SD	JP	JK	Cab	SDL	SEff
1. Job performance	78.8	13.3					
2. Job knowledge	74.4	17.8	.73**				
3. Cognitive ability	21.6	6.3	.64**	.63**			
4. SDL	3.2	1.8	.18	.21*	-.01		
5. Self-efficacy	20.4	4.1	.27*	.38**	.18	.25*	
6. Conscientiousness	2.7	.2	.26*	.24*	.17	.13	.33*

Note. N varied from 62 to 64, based on missing values.

* $p < .05$, ** $p < .01$

Table 2

Means, Standard Deviations, and Intercorrelations for SDL Activity Variables

Variables	Mean	SD	Class	Read	StGroup	PrTest	TalkPT	Study PT	AskHelp
1. Took class	.21	.41							
2. Read books	.47	.50	.38**						
3. Study group		.31	.47	.30*	.20				
4. Practice test	.57	.50	.02	.05	.21				
5. Talked / PT	.40	.49	.11	.23	.29*	-.15			
6. Studied PT	.55	.50	.12	.15	.16	.41**	.24		
7. Asked for help	.47	.50	.21	.24	.05	.32*	.23	.49**	
8. Other	.12	.33	.20	.19	-.13	-.21	.13	.02	-.13

Note. N = 58.

* $p < .05$, ** $p < .01$

Table 3

SDL Activity Factors

	Factor loadings		
SDL Activities	Factor 1	Factor 2	Factor 3
	Factor 1: Practice test, ask for help		
1. Studied PT	.84	.07	.10
2. Asked for help	.78	.12	.18
3. Practice test	.67	.13	-.58
	Factor 2: Formal class, study group, reading		
4. Took a class	.01	.81	-.01
5. Study group	.11	.68	.01
6. Read books	.13	.66	.24
	Factor 3: Talking to someone who took the practice test		
7. Talked / PT	.24	.20	.85

Table 4

SDL Factor-Criterion Correlations

	Factor scores		
Criterion Measure	Factor 1	Factor 2	Factor 3
1. Job Knowledge	.25*	.06	-.15
2. Job Performance	.20	.07	-.25*

Note. N = 58.

* $p < .05$.

Figure Caption

Figure 1. Results of SDL path analysis.

SDL Path Analysis Results