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Cross-Training at Peace River Pulp: A Case Study

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Executive Summary

In an increasingly competitive and innovative global economy, many Canadian companies have been attempting to increase their flexibility and ensure that their employees can adapt quickly and productively to new demands. Some companies have turned to cross-training—that is, to upskilling their workers across multiple jobs. Although large-scale surveys of hundreds of companies across North America have demonstrated the increased popularity of cross-training, researchers have found it difficult to determine whether cross-training programs are actually producing the desired results in particular cases. To help fill this gap, this study looks in detail at a successful cross-training program in one Canadian company—Peace River Pulp—located northwest of Edmonton, Alberta. Drawing on his in-depth interviews with company representatives, the author highlights the advantages and disadvantages of cross-training in various corporate environments and shows how to identify the strengths and weaknesses of particular cross-training initiatives. While the author emphasizes that each company is unique and therefore requires unique solutions to its problems, practitioners will be able to use this study to avoid many of the pitfalls of cross-training and to maximize many of its benefits.

- Employee productivity at Peace River Pulp is one of the highest in the industry. The company attributes this achievement to its cross-functional team system, which has shifted decision-making autonomy to the shop floor. It prefers to avoid written job descriptions or written policies concerning cross-training, since it feels that they would constrain the flexibility of the organization.
- Cross-training is particularly important in the pulping industry because of computerized control systems that require operators to have a well-founded comprehension of the entire pulping process. Cross-training allows employees to develop the intellectual mastery that has become a key performance factor.
- Cross-trained employees are less likely to resist technological innovation, since it is less likely to be perceived as a threat to their job security if they are used to moving from

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About the Author

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one skill to another and have been forced to deal regularly with technological change anyway.

- The more extensive the cross-training, the more difficult it is for employees to specialize in specific skill sets. Companies must therefore find a balance between special skills and a general understanding. One solution is to separate highly specialized jobs from the cross-training program.
- Skill-based pay is the most appropriate system for cross-training, but three problems may arise: it sometimes results in very high wage levels; employees may concentrate too much on acquiring new skills, rather than on completing their assigned jobs; and it is difficult to find new challenges for employees who have mastered all the designated skills. Only the last problem has arisen at Peace River Pulp, which finds it difficult to maintain a low turnover rate among its more experienced employees.
- Cross-training ensures that workers are idle only when there are no jobs to complete, not when there are no jobs that a particular worker can complete. It therefore allows companies like Peace River Pulp to use a ‘minimum-staffed’ strategy—to use only the minimum number of employees necessary to maintain production.
- Cross-training is particularly suited to the cost-reduction strategy of Peace River Pulp because it operates a continuous production system, within which it is very difficult to divide jobs into individual units. The more knowledgeable workers are about the whole process, the more proficient they become. Cross-training may not be so cost-effective in batch-production systems such as automobile manufacturing, however, where jobs can be broken down into simple, mundane tasks.

Introduction

In the past two decades, many Canadian companies have been responding to globalization, technological innovation, and changes in consumer preferences by attempting to ensure that their labour force can adapt quickly and productively to new demands (Weber and Verma 1999). The increased organizational flexibility that results can improve production quality and increase worker productivity. It can also increase employee satisfaction, thereby decreasing turnover and absenteeism and lowering the costs associated with recruiting, such as the cost of training and orientation (Cappelli and Rogovsky 1994, 211; Carmichael and MacLeod 1993, 144).

Different companies require different methods to increase organizational flexibility: some companies have turned to cross-training, that is to upskilling their workers across multiple jobs. In their study of six thousand North American Companies, Gittleman, Horrigan, and Joyce (1998) found that 12 percent were cross-training their employees throughout the company. In establishments that employed fifty or more workers, approximately 24 percent were placing their employees on job rotation. Furthermore, 76 percent of the companies surveyed provided or financed training that upgraded or extended employee skills or that qualified workers for a job. For companies that employed fifty or more workers, this figure increased to 95 percent.

Despite their increased popularity however, Upton (1995) notes that it is very difficult to determine to what extent cross-training practices are actually increasing organizational flexibility. Flexibility cannot be measured simply by counting the number of different products created by a company. Downtime and any delays that occur when a company switches from one product to another must also be considered, because cross-training can reduce costly downtime by improving the troubleshooting skills of its employees (Dunphy and Bryant 1996, 686). Furthermore, flexibility is not necessarily reflected just in products that are currently being created; it may also be reflected in products that could potentially be created. To determine this, the researcher must study the organizational structure of the company as well as the actual manufacturing process itself.

This study focuses on the cross-training practices at Daishowa-Marubeni (DMI), also known as Peace River Pulp, a pulp mill located approximately five hundred kilometers northwest of Edmonton, Alberta. Drawing on a detailed survey of company representatives, the author highlights the advantages and disadvantages of cross-training programs and shows how to identify the strengths and weaknesses of particular cross-training initiatives. More particularly, he shows that, as the experience at Peace River Pulp has revealed, any cross-training program must be unique, since it must cope with the unique problems that any company will inevitably face. The study also suggests, for any organization considering such a move, what critical factors must be in place in order to implement a successful cross-training program.

Cross-Training Influences: Maximizing Benefits

This chapter identifies several factors that have a significant influence on cross-training, in order to determine how cross-training can be designed to maximize benefits and minimize losses.

Any cross-training program must be unique since it must cope with the unique problems that any company will inevitably face.

Innovative Business Strategies and Organizational Flexibility

Cross-training promotes the necessary organizational flexibility and empowers workers with the knowledge required to do a given job without being restricted by the constraints of the organization.

According to Schuler, Galante, and Jackson (1987), there are three basic business strategies: cost reduction, quality improvement, and innovation. A company with an innovative strategy is probably the most suitable for cross-training initiatives. Organizations with this strategy focus on differentiating their products or services from those of their competitors, and they depend on an organizational structure that will allow the individual talents and abilities of their workers to thrive. Cross-training promotes the necessary organizational flexibility and empowers workers with the knowledge required to do a given job without being restricted by the constraints of the organization.

How Many Skills?

How many skills should workers acquire in a training program? Presumably there is a threshold where the costs of training in additional skills exceed the savings incurred by increasing organizational flexibility: that is, cross-training presumably follows the law of diminishing returns. Thus Park(1991, 298) found that the most significant improvement in flexibility occurred when employees were trained in two sets of skills instead of just one. An example of training in two skill sets would be training in the skills required for pipefitting and welding, rather than just pipefitting alone. Brusco and Johns (1998, 511), who studied cross-training in a paper mill, also found that the benefits of flexibility associated with cross-training were the most substantial for employees who had mastered two complete skill classes.

Chaining

Another issue that pertains to flexibility is ‘chaining,’ which requires each worker to train in a unique combination of skills (Brusco and Johns 1998). Consider the following example of chaining. A pipe-fitter is required in the maintenance department of a pulp mill. Employee A is trained in both pipe-fitting and welding, but he is currently working on a job involving the latter skill. Conversely, employee B, who is currently free from any immediate work tasks, is trained in both welding and lubrication. While she cannot complete the pipe-fitting task, she can complete employee A’s current job.

Brusco and Johns (1998, 505) argue that an asymmetric training program is much more conducive to chaining than a symmetric training program. A symmetric program would, for example, cross-train electricians in instrumentation, and it would cross-train employees skilled in instrumentation as electricians. In an asymmetric program electricians might be cross-trained in instrumentation while employees skilled in instrumentation might be cross-trained in any skill other than electrical services—in welding, for example. Since each worker is generally trained in a unique combination of skills, asymmetric training creates a work environment more conducive to chaining.

However, if a training program produces worker skill sets that are too diverse, it may turn out that too few employees are trained in the high-workload jobs of the organization. Hence, these jobs may not be filled in the way that is required in high-demand situations. Clearly, then, cross-training policies must reach a balance between training workers in diverse skill sets and training for high work-load jobs.

Generalists or Specialists?

When implementing cross-training, companies must also find skill-sets and a general understanding of the manufacturing process. The more extensive the cross-training program, the more difficult it is for employees to specialize in specific skill sets (Stanislaw et

al. 1994, 351). On the other hand, they will be able to provide assistance for many jobs that are not highly specialized. Which direction should the upskilling program lean to, specialization or well-rounded, extensive cross-training? Sometimes, this problem can be avoided by separating highly specialized jobs from the cross-training program.

Another solution is to have each worker completely specialize in one skill and master at least 50 percent of another skill set. Brusco and Johns (1998, 511) found that when employees are cross-trained in this way, about 87 percent of the cost savings available from completely mastering the second skill set were attained, on average.

Two Forms of Flexibility

Organizational flexibility takes one of two forms: uniformity flexibility or product-range flexibility. Product-range flexibility refers to a plant's ability to switch smoothly from an old product to a novel product; an example would be an automobile assembly factory where a different car is produced each year. A company requiring this kind of flexibility should focus on educating its workers with general trouble-shooting skills that are not specific to a particular product. Uniformity flexibility, on the other hand, refers to a plant's ability to smoothly switch back and forth between different products; an example would be a pulp mill, where production constantly switches from hard wood pulp, an aspen-derived product, to soft wood pulp, a spruce- and pine-derived product. These plants should focus on educating their employees with skills specific to the manufacturing process, for they will be of the most benefit. This places obvious limits on the breadth of cross-training at a company like Peace River Pulp.

Technological Innovation

Cross-training has become particularly important in the pulping industry as a result of technological innovation. Perhaps the most significant example is the Distributed Control System (DCS), which measures various physical properties of the pulp manufacturing process, such as the rate flow of pulp and the temperature of the pulp machine. The DCS can also be set to 'cascade' so that the process controls become self-adjusting. As a result, the responsibilities of the operator have started to shift away from tending directly to the actual pulp manufacturing process and towards operating and maintaining the DCS. The operator is now burdened with conceptualizing what is happening beyond the computer screen and making the proper adjustments on a keyboard. In order to do this, the operator needs not only to understand how to use the DCS; she or he must also have a well-founded comprehension of the pulping process. In other words, intellectual mastery becomes a key performance factor (Adler 1986, 18).

Cross-training provides an opportunity for workers to develop the well-founded comprehension of the pulp manufacturing process that the DCS demands. Multiskilled workers are more likely to understand the overall production process and the exact causes of its various elements than single-skilled workers (Park 1996, 281). 'As team members multiskill, they acquire a broader understanding and appreciation of how the full range of skills needed for the task can be combined in an optimal way to produce the finished product or service' (Dunphy and Bryant 1996, 686).

However, multiskilling does not appear to be effective when the training involves high skill-complexity or low task-interdependence (Dunphy and Bryant 1996, 686). Such training results in an increase in production errors. This is especially important in the context of highly integrated computer systems, since they are very sensitive to error (Alder 1986, 19). A pulping plant cannot afford operators making even the smallest mistake on

Cross-training has become particularly important in the pulping industry as a result of

the DCS, for it can snowball into a problem that may result in expensive downtime. Operation of technology like the DCS thus requires specific one-on-one training. Therefore, although it may be advantageous to cross-train workers in some jobs in order to give them strong knowledge of the pulping process, it may be detrimental to cross-train workers on multiple DCS panels in the hope of giving them a strong understanding of the DCS. In fact, due to the extensive time required to master such highly specialized jobs, they should perhaps not be included in the job rotation (Wright 1998, 69). Too much time would be spent training everyone concerned, and too much information would be lost while workers were rotated through the various positions.

Sociological Consequences

As technology becomes more complex in the pulping industry, a rift develops between shop floor workers and engineers, who typically seem to possess the most thorough knowledge of pulp manufacturing and therefore tend to be hired most frequently for management positions. As a result, the management staff is literally separated from the shop floor workers, and very few managers are 'likely to share the same . . . assumptions as their manual coworkers, to speak the same "language", and to valorize craft expertise' (Vallas and Beck 1996, 356). Vallas and Beck suggest that pulp mills should therefore, attempt to promote policies and practices that could realistically promote local workers into management positions. Multiskilling would do just that by giving workers on the shop floor the diverse skills they would require in management positions.

Technological change can also create friction between workers and management because workers may resist the implementation of new innovations, which may be perceived as a threat to job security. Cross-training can effectively reduce such resistance, for two reasons (Carmichael and Macleod 1999, 144). First, cross-trained workers will not find technological change to be as much of a threat to job security as single-skilled workers will since they will be able to move from one job to another when change does occur. Second, cross-trained employees will less likely to feel intimidated by technological innovations, since they are forced to deal with new technology much more frequently anyway.

Continuous Production

Because pulp processing is a continuous production system characterized by the continuous generation of output, workers need to acquire as much control over and knowledge about the production process as possible. Any mistake created in one department can have a rippling effect, creating problems in other departments. Hence, employees must try to prevent a problem before it occurs. To do so, they require in-depth knowledge of the production process. Cross-training employees so that all workers are able to see as many aspects of the process as possible helps them to acquire it.

Furthermore, like all continuous production processes, pulp manufacturing requires effective and rapid communication between operating departments (Vallas and Beck 1996, 345). The entire plant must adapt as quickly as possible to any problems. For example, a significant 'break' in the pulp machine, which is at the last stage of the manufacturing process, will require other operating departments to slow down fairly quickly. Rapid communication is therefore crucial. Cross-trained employees working in contiguous departments will have a better idea of what information is valuable and what information is useless to the personnel in each operating area. In such extreme conditions as a break in the pulp machine, these employees will be able to communicate with other departments as quickly and as efficiently as possible.

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However, there is also a drawback to cross-training such operators. Many of the employees that are required to communicate to other departments are also responsible for operating the DCS for their area. As mentioned earlier, it may be disadvantageous to rotate workers through interdepartmental DCS skill training, since it involves a high degree of skill complexity. The organization is therefore faced with a dilemma and must either find an alternative method of reducing errors or decide which is the lesser evil—errors created between departments or errors created within departments.

Skill-Based Pay

Klein (1998, 69) suggests that skill-based pay is the most appropriate compensation system for cross-trained employees, who are regularly rotated through different jobs. Because employees are paid for the relevant skills, abilities, and knowledge they can apply to the manufacturing process, rather than for a job position that they have been assigned to, skill-based pay does not limit their mobility. Under a traditional system, an employee might have to be paid as an operator when running machinery, for example, and as a mechanic when repairing it. This system would therefore be more expensive to administer than skill-based pay, under which an employee would receive the same pay regardless of the job performed.

Skill-based pay is particularly advantageous to a pulp manufacturing process because, as mentioned, it is desirable for employees to have as much control over the manufacturing process as possible. Skill-based pay will help motivate employees to learn the necessary skills.

Skill-based pay does have disadvantages, however. Hourly labour costs are significantly higher than in a traditional compensation system, because employees are compensated for all the relevant skills they have learned, not just for completing an assigned job (Celani and Weber 1999, 20). Furthermore, problems may arise when an employee has learned all the required skills and is in the top pay category, because there will be no room for further pay increases, and there may be no room to advance to the next level of the company. If these problems are not handled properly, turnover of the more highly skilled employees may increase.

Under skill-based pay workers may also begin to emphasize acquiring additional skills over other, higher work priorities (Klein 1998, 74). A poorly designed system may also encourage workers to learn skills that are of little benefit for the manufacturing process.

The Organizational Structure

The 'Minimum-Staffed' Strategy

Cross-training may affect the organizational structure of the company. Perhaps the greatest change is that workers may be idle when there are no jobs to complete, not when there are no jobs that particular workers can complete (Knights and McCabe 1998, 174; Park 1991, 298). This advantage may result from one of two types of strategies. If the company focuses on cost savings, it may pursue a 'minimum-staffed' strategy: it may staff only the minimum number of workers needed to run the facility. Cross-training allows management to decrease labour costs by decreasing the number of workers who are needed, because more jobs can be assigned to fewer people in a cross-trained environment. For example, if maintenance workers are allowed to specialize in only one skill, such as welding or machining, then the company must have one welder and one machinist on-site at

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Cross-training will have a significant impact on the autonomy of workers on the shop floor.

all times. But if maintenance problems are infrequent enough, a worker who is trained in both welding and machining can do the jobs of two workers, cutting labour costs in half.

A second strategy may be employed by organizations facing much more rapid and dynamic changes that dramatically increase the number of workers required on-site. Such organizations may continue to have more workers than they require because the costs of downtime that they avoid by overstaffing exceed the labour costs that are incurred. Felan, Fry, and Philpoom (1993, 2488) refer to this overstaffing as 'capacity slack.'

Worker Autonomy

Cross-training will have a significant impact on the autonomy of workers on the shop floor (Aoki 1986; Wright 1998, 69), since it can empower employees with the decision-making skills they require to work independently of supervision. For example, Park (1996, 260) found that cross-trained workers are better suited to deal independently with new and different problems and products than workers trained in a single skill. Properly cross-trained employees also tend to be better at troubleshooting and fixing malfunctioning equipment. If a company does choose to increase worker autonomy, this can have a significant flattening effect on the hierarchy of the organization and particularly on lower-level managers who are responsible for supervising employees on the shop floor (Aoki 1988). Hence, these managers may resist cross-training practices. In fact, any worker who possesses a job that will be significantly damaged by cross-training typically will resist the program (Cappelli and Rogovsky 1994, 217; Rinehart, Huxley, and Robertson 1997, 57).

Once cross-training has been practised for an extended period, the facility may mature to the point where all immediate supervisors are also cross-trained. When the workload increases significantly, these immediate supervisors will therefore be able to help out on the shop floor. Similarly, if one department becomes burdened with an excessive workload, an organization with a fully cross-trained staff may be able to shift individuals from other departments to the overburdened area.

Employee Mobility

The enhanced employee mobility that results from cross-training will decrease the number of employees who follow traditional career paths. If the skills required for management positions are specific and rigid within an organization, cross-training could have negative consequences for promotion policies (Méhaut 1988, 452). Although many employees will possess diverse skills, it is possible that few of them will have the *traditional* combination that management requires for higher-level positions, and management might therefore hire employees from outside the organization. A diminishing number of promotional opportunities would then ripple down the organization to other groups of workers.

Employee Resistance

While employees may resist cross-training initiatives, thereby reducing the chances of success, worker resistance will tend to lessen the more they are involved in such initiatives (Carmichael and Macleod 1993, 144). Cross-training will also tend to reduce the 'that's not my job' mentality in the work force (Klein 1998, 69).

Resistance is also affected by how workers perceive the rewards for increased learning. In their study of a cross-training program at an Australian minerals processing plant, Cordery, Mueller, and Sevastos (1992, 273) found that some employees felt the training, work, and responsibility required were not worth the increase in pay being offered. They

chose to stay in the positions they had occupied before the implementation of the initiative. However, as the cross-training became more entrenched in the organizational culture, the number who refused to participate began to decrease.

Cross-Training in Practice

The Interviews at Peace River Pulp

The information about Peace River Pulp that is presented in this study was obtained through fifteen semi-structured interviews, using a set of general questions; the author explored specific aspects of cross-training in the company during the interviews. Each interview typically lasted sixty to ninety minutes. The interviews were originally constructed so that at least one person in each department was represented and so that the interviewees were generally the most knowledgeable about their department. As it turned out, most of the original appointments happened to be with management personnel. Hence, additional interviews were scheduled with people that worked directly in the production process.

To protect the anonymity of the people surveyed in this study, the results are presented as a collective whole, not on an individual basis.

The Manufacturing Process at Peace Rive Pulp

Peace River Pulp, a Japanese-owned company, is a nonunionized mill that was constructed in 1989 as a greenfield plant. The plant started operations in July 1990 and began to produce hardwood pulp, an aspen-derived product, and softwood pulp, a spruce- and pine-derived product. Mill production has subsequently improved to the point where output is 20 percent higher than was originally planned.

Home Station Groups

There are approximately 342 permanently employed plant workers, 100 contractually employed workers, and 250 seasonally employed forestry workers. Sixty percent of the permanently employed workers have had no previous experience with traditional management systems in the pulping industry, while 30 percent came directly from academic institutions and had little or no work experience. This obvious attempt to develop an organizational culture ignorant of traditional management systems stems from a desire to establish cross-functional teams called Home Station Groups (HSGs), which depend on a participative style of management. Each of the fifteen HSGs is responsible for a specific aspect of the manufacturing process, and is composed of approximately twelve technicians, together representing people from all process-related departments in the mill. The HSGs are distributed throughout the six organizational departments of the facility. These are:

- 1 Woodlands, which is responsible for harvesting, log hauling, log storage, and chipping.
- 2 Operations, which is responsible for monitoring and operating the pulp manufacturing process.
- 3 Technical, which is responsible for process engineering, quality control, and operation of the environmental and central lab.

Cross-training throughout operations is, for the most part, administered through a seven-tiered 'technical-progression' system.

- 4 Mechanical Maintenance, which is responsible for numerous maintenance tasks, such as repairing machinery, welding, and pipefitting.
- 5 Electrical Services and Instrumentation, which is responsible for instrumentation and process-control maintenance.
- 6 Engineering, which is responsible for project design and implementation.

The HSGs are responsible for developing and maintaining training manuals and operation procedures, planning and scheduling maintenance work, and recommending and approving changes to the pulp production process. They have no responsibility for human resource issues at Peace River Pulp. Collectively, an HSG has authority only to the group leader, the operating superintendent.

Several other departments exist outside the HSGs, including human resources, computer support, and management. Representatives from these departments may attend HSG meetings.

Cross-Training Practices

Operations

Cross-training in the operations department can be broken down into four separate upskilling programs. Each program is designed for a different sub-department of operations—the woodroom, pulping, steam and recovery, and the pulp machine—and is confined to the particular needs of each sub-department. Hence, no one is allowed to train simultaneously, or work for that matter, in two different sub-departments.

Cross-training throughout operations is, for the most part, administered through a seven-tiered 'technical-progression' system. Employees working at the lowest tier are called technician trainees (TT); they have few or no skills listed in the company's training protocol. After completing this training, they advance to the next tier (sixth-level technicians), where they receive a pay raise and increase the breadth of their job rotation. They are also expected to start training for skills in the next (fifth) tier after the promotion. This cycle continues until they advance to the highest position in the technical progression system (first-level technician).

There are a few important points to note about this seven-tiered cross training program. First, because each tier builds on the skills established in the earlier level, one is not allowed to skip tiers. Second, each tier is standardized, so that all employees are learning the same skill sets when they advance through the system. Third, the job rotation is constructed so that workers do not have to compete for positions. However, because only a limited number of workers can train while the pulp mill is operating, workers must cooperate or compete for the distribution of training time. Training problems can also arise if many workers in the same tier are on a particular shift, since all the workers will be competing for training in the same area.

Employees who have become first-level technicians, have been educated in all the skills required in their sub-department. First-level technicians can run any of the relevant machinery. Hence, there is no room for future pay raises if they stay in the technical progression system. However, by the time employees have become first-level technicians they have also developed a strong knowledge of the pulp manufacturing process and have been trained in leadership skills, and they may often be asked to manage the sub-department they work in when it is short-handed. They may, as well, compete for the position of shift lead, which involves managing the employees they work with and which is not part of the technical progression system. Advancements beyond lead positions are locat-

ed in middle management and do not require any cross-training. Leads compete with engineers and other professionals for these positions.

While the cross-training program is fundamentally the same in each sub-department, there are important differences. The woodroom is unique because the skill-level required for training is significantly lower than what is demanded from other sub-departments. Employees in the woodroom are primarily concerned with learning how to operate heavy machinery and feed wood chips to the pulp mill, while workers in the remaining sub-departments must learn the chemistry and physics of pulp manufacturing, a much more difficult task, requiring years to complete. Because of this difference, there are only five tiers in the technical progression in the woodroom, instead of seven, and the pay level is lower than in other sub-departments.

When technical problems require the entire pulp mill to shut down, workers in the woodroom stop feeding chips into the system. Since there is no work in the woodroom to complete during a shutdown, the company decided to cross-train woodroom workers in skills related to other sub-departments so that the woodroom can help restart the mill as quickly as possible. Furthermore, new recruits for operations positions are typically only hired for the woodroom, and positions that become available in any other sub-department are usually given to woodroom veterans. Because the woodroom requires relatively less skill and ability than any other department, less money is therefore spent on recruits who may prove unsuitable for hiring within the mill. The workers who are trained for positions in other sub-departments, on the other hand, are those who have demonstrated a strong work ethic, team-skills, and commitment to working at Peace River Pulp.

Woodlands

The woodlands department consists of only twelve employees who are responsible for administering the contract work to forestry companies throughout northwestern Alberta. Because these positions require a great deal of training in forestry, the department has its own customized cross-training program. Forestry personnel typically specialize in a specific aspect of their profession, such as silviculture or chip procurement, but they are rotated into a different position every two to four years and are consequently able to work in many aspects of forestry. Employees do not receive additional pay for their cross-training, however. The company argues that their reward for cross-training is the extra experience offered by the program.

The cross-training program allows woodlands to be more flexible for two reasons. First, when confronted with a new and unique problem, employees can consult with other foresters who have previously worked in the same position. Second, if an individual leaves the company or becomes sick, other employees can temporarily absorb the workload.

Mechanical Maintenance

Like the operations department, the maintenance department relies on a technical progression system in which employees advance through seven tiers of training, after which they are eligible to apply for one of the departmental lead positions. Each set of skills that employees obtain makes them eligible to expand the breadth of their job-rotation. The company encourages training in all disciplines of mechanical maintenance. Furthermore, workers are encouraged to pursue two, or even three, journeyman tickets. Consequently an employee may, for example, be proficient both as a pipefitter and as a millwright. As in the woodlands department, the company does not compensate employees for obtaining their second or third journeyman ticket but argues instead that the reward for cross-training is the extra experience offered by the program.

The cross-training program allows woodlands to be more flexible.

Maintenance workers are also cross-trained in the sense that they are rotated throughout all the sub-departments of operations. For example, an employee in the maintenance department may be repairing equipment in the pulp machine today and working in the woodroom tomorrow.

Accounting

In 1995, three accountants left Peace River Pulp within months of each other. To avoid such turnover problems, employees are now rotated within the department every two to four years, depending on their abilities. The accountants therefore have a reason to stay with the company for a longer period, since they will acquire more experience than they would at most other places, and the department now has the time it requires to plan and adapt.

Electrical Services and Instrumentation (E & I)

Although the pulp manufacturing industry usually treats electricians and instrumentation employees as members of two separate professions, Peace River Pulp amalgamated the two departments completely: every electrician is also expected to train in instrumentation, and vice versa. Because individuals trained in both professions can find job opportunities in other industries, such as oil and gas, this cross-training practice has helped protect the company from higher turnover.

In other respects, the technical progression system in E & I is similar to the systems in the maintenance and operations departments.

Cross-Training between Departments

In August of 1998, the woodroom began a program of training its workers in minor mechanical maintenance skills, in order to deal with the increasingly frequent repairs required by the machinery in the woodroom. As a result of their training, employees were able to fix problems on the spot without calling in outside contractors, and they were also able to forecast future problems. They consequently developed a better understanding of the limitations of the equipment and how to use it properly.

Analysis of Cross-Training at Peace River Pulp

Business Objectives: Cost Leadership

Peace River Pulp's business strategy focuses primarily on cost leadership. The fundamental features include intensive supervision of work and labour costs, a managerial focus on controlling activity costs, minimizing investments in staff training and development, and avoiding unnecessary overhead and administrative costs.

While literature predicts that companies with such a strategy would place a low priority on cross-training and that they would see the benefits of cross-training in lower labour costs, not in increased organizational flexibility, this thinking is not immediately apparent at Peace River Pulp. For example, cross-training was accepted at the management level because it was believed that it would enable the company to run the mill with the smallest possible labour force. The company believed it could save more money with a minimum-staffed approach (to use a term introduced earlier) than with a minimum-training approach.

However, many of the managers tended to focus only on the immediate cost savings produced by the minimum-staffed approach. They did not recognize that cross-training can

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also improve trouble-shooting and team skills, which can result, in turn, in long-term savings. Hence, management would support cross-training only within specific limits.

The cost-savings strategy did, however, provide some indirect support for cross-training. For example, recruitment at Peace River Pulp promotes cost-containment by cross-training and promoting only internal employees with strong team skills and commitment and hiring externally only for entry-level jobs in the woodroom. Consequently, training lost to attrition is minimized as much as possible. Furthermore, management encourages employees to do whatever is required to get a job done as cheaply (and safely) as possible. If extra training is required to complete a task, management will support it as long as it ultimately produces savings. This support from management has given employees partial flexibility and autonomy, and it can only help any cross-training efforts.

The company's cost-saving strategies have also led it to contract out any work that is sporadic or unpredictable. Permanent employees are therefore able to concentrate on the essential aspects of the pulp manufacturing process, and cross-training can be focused on areas where cost-savings can be incurred consistently.

Human Resources

The fundamental human resource management philosophy at Peace River Pulp is 'participative management,' which provides the rationale for the Home Station Groups outlined above. Employee productivity at Peace River Pulp is one of the highest in the world, and the company attributes this achievement to the cross-functional HSGs, which have shifted decision-making autonomy towards the shop floor.

To further promote flexibility, the company has no written job descriptions or policies concerning cross-training practices, except for a description of the technical progression systems. Management feels that written descriptions would constrain the flexibility of the organization. For example, the company is planning to train all workers in the operations department with minor maintenance skills and feels that job descriptions would inhibit such upskilling initiatives, since it would have to formally modify all job descriptions in the department.

Organizational flexibility

It was very difficult to determine the cost-savings that result from cross-training at Peace River Pulp, because most of the cross-training practices existed since the pulp mill was created. Furthermore, even if costs or benefits could be identified for cross-training initiatives, it would be hard to determine if they were a direct result of cross training or the result of some other variable, such as environmental conditions. It can be said, however, that, as mentioned earlier the greatest benefit from cross-training occurs when a company switches from training its employees in one skill to training them in two skills (Park 1991, 298). This condition is certainly being met at Peace River Pulp.

As was also mentioned earlier, literature reveals that companies must find a balance between training workers in diverse skill sets (to promote 'chaining' and cross-training for high-workload jobs. Since each department at Peace River Pulp has a different type of cross-training program, the balance obtained is different in each department. In both operations and electrical services and instrumentation, the cross-training programs are standardized and rigid. Because each tier provides the prerequisite skills for the next tier and because employees must follow the pattern of training dictated by the whole system, individuals are unable to develop unique combinations of skills, making it very difficult to 'chain' during large problems. This problem is evident in the higher tiers, since these higher levels require the greatest number of skills.

Support from management has given employees partial flexibility and autonomy, and it can only help any cross-training efforts.

Hence, to increase flexibility and provide more opportunities for chaining and cross-training high-workload jobs, the company needs to determine how the training programs can be restructured so that there are fewer prerequisites for higher tiers in the system. In other words, the company would move from a hierarchical training program to a more integrative program, and employees would select the training that the organization currently demands, instead of being restricted by the training options provided in the technical progression system.

Environmental Pressure

Any economic downturn, especially in the Asian market, can significantly reduce revenue at Peace River Pulp. If a recession is serious enough, the company may be forced to reduce its investments in cross-training. This problem did arise during the 1990s. Sale prices were low during the entire decade, and as a result, investments in training were slowly decreased. But most of the cutbacks have so far not affected cross-training initiatives, because they are either fundamental to the organizational structure at Peace River Pulp or were actually established as a means to reduce departmental costs. In fact, any significant cutbacks in the cross-training initiatives would be a sign that the organization is in deep economic trouble.

The oil industry has been growing rapidly in Alberta, increasing the demand for electricians and instrumentation workers in western Canada. Peace River Pulp has attempted to ensure that its employees will not be drawn into this industry by offering them the opportunity to specialize in both instrumentation and electrical services. Not only does this provide them with additional challenges, but it also allows them to make themselves more marketable in the long run. Hence, turnover at Peace River Pulp remains at a satisfactory, low level.

Technological Innovations

Peace River Pulp uses its cross-training initiatives in accordance with the suggestions found in the literature. For example, cross-training helps to build a foundation for understanding the pulp production process as a whole, which is fundamental for anyone who is operating the Distributed Control System (DCS). However, employees are not cross-trained on multiple DCS panels, for the high skill complexity involved in such initiatives could possibly lead to costly downtime.

Troubleshooting

As technology becomes more complicated, it is important to improve the trouble-shooting skills of employees. One way to do so is through cross-training. During 1998, 37 percent of lost production was deemed avoidable and for 60 percent of lost production it would have been possible to prevent small, unavoidable problems from developing into large ones. In other words, only 3 percent of lost production was completely unavoidable. Clearly, the company would benefit from improving the troubleshooting skills of the employees at Peace River Pulp.

While Peace River Pulp does cross-train extensively in each department, it does not cross-train extensively between any departments, except, as mentioned, for the wood-room. Cross-training between departments could be beneficial in many trouble-shooting scenarios. For example, if employees in operations were trained in minor mechanical maintenance skills, they might be able to forecast when a particular piece of machinery would run into mechanical problems.

Cross-training helps to build a foundation for understanding the pulp production process as a whole.

Culture Segregation

As mentioned, as technology becomes more complex, workers on the shop floor know less about pulp production than the engineers. The engineers, who are then segregated culturally from workers on the floor, are therefore more likely to progress into management. While the literature suggests that cross-training workers on the shop floor would help reduce the differences between these two groups, Peace River Pulp has provided a different solution. Because in the past, leaders who may have had strong technical skills but no leadership skills had mismanaged some important personnel issues in several departments, it now requires its managers to have strong communication and directional skills, not technical skills. Hence, the difference in the technical knowledge of employees does not affect promotion.

Responding to Innovations

The literature suggests that cross-training helps to reduce employee resistance to operating new machinery. Peace River Pulp did recently install a new dry-end scanner, a machine which is designed to assess the quality of the pulp just before it is cut into bales. The scanner could eliminate a job located in the pulp machine, which is also responsible for assessing the quality of the pulp. Nevertheless, none of the interviews revealed any worker resistance to this innovation, although it could not be determined whether the lack of resistance was a direct impact of the cross-training program.

Continuous Production

The literature emphasizes the importance of communication in a continuous production system. Cross-training allows employees to develop a thorough understanding of the pulp production process, enabling them to effectively communicate any information that is required. However, as mentioned, there is little interdepartmental cross-training at Peace River Pulp, with the exception of the initiatives in the woodroom and operations and mechanical maintenance.

The company does allow workers to apply for a career change between departments and, as a result, there are a few employees who do have an extensive knowledge of more than one department or sub-department. However, many employees are forced to take a decrease in pay when they make this change. For example, first-level technicians who switch from the maintenance department to the operations department automatically become third-level technicians, which provides a lower form of compensation.

Compensation

Skill-Based Pay

As mentioned, skill-based pay is the most suitable compensation system for cross-training programs, but it has three disadvantages: it sometimes provides very high wages to employees; it is difficult to determine what should be done when an employee has mastered all designated skills; and employees may place a higher priority on acquiring new skills than on completing assigned jobs.

Peace River Pulp uses two different types of pay for its cross-training initiatives. The first, skill-based pay, is deeply entrenched within the technical progression system. This system is used for the mechanical maintenance department, the operations department, and the electrical services and instruction (E & I) department. Under this structure, each advance to another tier in the technical progression system brings a standardized wage

Skill-based pay is the most suitable compensation system for cross-training programs, but it has three disadvantages.

increase. Some of the disadvantages of skill-based pay emerge here. The mill finds it difficult to maintain a low turnover rate with its more experienced employees. When employees become first-level technicians, the only opportunity they have for advancement is to apply for team lead competition, for which there are usually only four positions per department. Hence, experienced employees who can no longer find the challenge they would like at Peace River Pulp typically end up leaving. Since jobs in both E & I and maintenance involve skills that are required in many industries, these departments have the greatest potential for turnover problems. The operations department, on the other hand, only trains workers with skills specifically related to pulp manufacturing. Hence, highly skilled employees in this department have fewer alternatives, and the potential for turnover is much lower.

The problem of employees placing greater priority on training than on completing assigned tasks rarely appears at Peace River Pulp. Nor do wage levels seem to be a problem. The company pays market wages, which are determined by a pulp industry consultation organization. That is, employees in all departments are paid wages that are competitive with the pulp manufacturing industry in western Canada.

The Hay Scale

In addition to skill-based pay, Peace River uses a structure called the Hay Scale in the accounting and woodlands departments. The Hay Scale is based on experience and relative performance. Workers typically begin at a level that is anywhere from 65 to 90 percent of the market wage, depending on their experience. Every year they receive a 2 percent increase in salary. Once they reach 100 percent, there is no longer any room for further raises based on experience, but they can receive an increase if they perform better than most other individuals in their department. The top performer is often given roughly a 4 percent raise the annum following an outstanding year, while other workers in the top 25 percent are given a 1 to 2 percent raise. Furthermore, if these employees remain at their level of output, they either maintain the raise or receive another 4 percent raise, depending on how they perform relative to the rest of the department. If performance decreases, the raise is taken away. Employees are able to earn a salary that is a maximum of 110 percent of the market wage.

Under the Hay Scale employees are often paid less than the market wage, since inexperienced workers are paid below the industry standard. However, as with the pay-for-knowledge system, turnover among experienced workers is a potential problem with the Hay Scale, although not to the same extent. Since workers are paid for performance, there is always potential for increased compensation with employees in woodlands and accounting. However, experienced employees, especially in accounting, are high in demand. Hence, although the Hay Scale helps decrease turnover, it does not prevent it.

Safety

If vocational injuries are related to chronic stresses, cross-training will tend to decrease the chances of injury, since the physical stress of the job will be distributed amongst numerous workers. However, most of the injuries at Peace River Pulp are accident-related, not chronic. When attempting to prevent accidents, it is very difficult to determine how much safety training is too much for workers to remember while participating in a cross-training initiative: how much is too much can be determined only through experience. The company therefore needs to investigate whether the accidents that have occurred were due to insufficient training, job rotations that are too short in duration, or jobs that require too much safety instruction to be realistically involved in the cross-training program.

Cross-training will tend to decrease the chances of injury.

The Organizational Structure

Cross-training ensures that workers are idle only when there are no jobs to complete, not when there are no jobs that a particular worker can complete. As mentioned, organizations can take advantage of this situation by using a minimum-staffed strategy. Accordingly, Peace River Pulp tends to use only the minimum number of employees necessary to maintain production. This probably suits the company's production needs, since there are few instances when the costs of downtime would exceed the labour costs required to operate at less than full capacity.

Peace River Pulp has benefited from the fact that cross-training often empowers workers with a significant amount of autonomy. For example, the cost-reduction strategy encourage workers to find innovative methods to reduce overhead. Furthermore, the company has slowly been flattening its hierarchy during the last decade. Just recently, the shift supervisor positions were eliminated, and that job responsibility was transferred to the shift leads, who are now expected to help workers on the shop floor when they have too many problems to deal with. There is, however, little shifting of workers between departments, except in the case of low-skilled jobs.

Employee Resistance

Any negative labels placed on a cross-training initiative will have a detrimental effect on its potential success. An example is provided at Peace River Pulp by a proposal to cross-train operations employees with minor mechanical maintenance skills. While many operations employees were excited about such an endeavor, many of the mechanical maintenance workers displayed an 'us and them' attitude and did not want operations workers meddling with jobs that they would have to fix later. In fact, the 'us and them' attitude prevailed throughout the entire mill. While most employees were very proud of the cross-training programs they were participating in, many also resisted the idea of expanding the breadth of their job rotations to other departments of the mill. For example, some people thought that a maintenance worker could not do an electrician's job without a high frequency of injuries, and vice versa.

This attitude has affected how employees in different cross-training programs work with each other. For instance, if a motor breaks in the pulp machine, an employee from mechanical maintenance might determine that there is an electrical problem and call someone from electrical services to repair the motor. However, that person might determine that there is a mechanical problem and call the employee from mechanical maintenance back to the scene. While each worker is calling the other, the costs associated with downtime will be increasing, but the motor may in fact require both mechanical and electrical maintenance. The 'us and them' attitude may have prevented either worker from reaching this conclusion.

Employees may also resist cross-training if they believe that the extrinsic rewards are not sufficient. For example, many employees in the woodroom at Peace River Pulp do not wish to be involved in the cross-training program between their sub-department and operations, and they have therefore missed opportunities for promotion to other areas of the mill. These employees will never leave the woodroom, but in fact none of them *wants* to leave the woodroom. Instead, they have become the teachers of their sub-department. When fresh recruits are hired, the seasoned individuals train the new employees in all the necessary skills. Who better to train new employees than the most experienced woodroom workers at Peace River Pulp? This demonstrates that not all resistance has a negative impact on the

Any negative labels placed on a cross-training initiative will have a detrimental effect on its potential success.

organization. Note, however, that these employees, and others found in the rest of the mill, add congestion to the organizational dynamics of the company by occupying the same job for long periods of time and making it difficult for others to progress to different positions.

Conclusion

For the most part, the cross-training practices at Peace River Pulp are consistent with what is recommended in the literature. Many of the programs were designed to help workers develop a working knowledge of the pulp manufacturing process. This has helped them work effectively with such technology as the Distributed Control System. The company has also focused on training workers with skills that are specific to pulp manufacturing, as recommended in the literature, and it has focused on cross-training in high-turnover departments, to reduce turnover. Furthermore, cross-training has been designed for a minimum-staffed production system, as was suggested in the literature.

Interdepartmental Training

Nevertheless, differences between facility practices and the literature can be found in a few areas. For instance, there is not a significant amount of interdepartmental cross-training at Peace River Pulp, even though the company needs the improved trouble-shooting skills that interdepartmental cross-training can produce. Both management and the workers have resisted interdepartmental cross-training out of a common belief that any attempt to combine the duties of different departments in cross-training initiatives would ultimately fail.

Continuous Production

Many of the ways in which Peace River Pulp has departed from the recommendations of the literature have been for the better, however. As noted, the company has found that cross-training can be effective in a cost-reduction environment because it operates a continuous production system, while many of the cross-training programs studied in the literature pertained to batch-production systems, such as automotive manufacturing. In such industries, a Tayloristic strategy is very efficient at promoting cost-reduction, because jobs can be broken down into simple, mundane tasks. Hence, companies that use cross-training in any batch-production industry will have the burden of extra labour costs in comparison to other companies that follow Tayloristic cost-reduction strategies.

A Tayloristic strategy is not viable in a continuous production system since most workers are responsible for monitoring the production process, not actually manufacturing specific parts. Hence, it is very difficult to divide jobs into individual units. In continuous production, the more knowledgeable the workers are, the more proficient they become. For example, as mentioned, interdepartmental cross-training can improve trouble-shooting skills, which are essential for reducing costs in a continuous production system.

Skill-Based versus Performance-Based Pay

While the literature recommends a pay-for-knowledge system, in many instances the company chose the Hay Scale, which is a performance-based system. This was not a problem, however, since both employees and management mentioned that the benefit of working within the cross-training programs was the experience that was provided, not the increased monetary incentives.

*Cross-training can be effective
in a cost-reduction environment
because it operates a
continuous production system.*

Reducing Paperwork

To add flexibility to the organization, Peace River Pulp did not want to establish the cross-training as official policy. As a result, whenever an employee or home station group recognized a need for change, the paperwork required was minimal.

Employee Mobility

As we have seen, and contrary to what is often stated in the literature, worker mobility may not be a problem with cross-training programs. Because management at Peace River Pulp stressed that its leaders must have excellent communication and directional skills, not technical knowledge, cross-training did not adversely affect the mobility of employees. That is, workers were not punished for pursuing unconventional career paths.

Employee Resistance

Perhaps the most important insight provided by this case is that small forms of resistance may actually benefit a cross-training initiative. This was particularly evident in the woodroom, where employees who did not wish to participate in the cross-training program acted as teachers to new recruits. This system may prove invaluable to Peace River Pulp, since injuries typically occur among employees who have worked less than four months at the mill. Having experienced teachers can only improve the safety of operations.

Small forms of resistance may actually benefit a cross-training initiative.

Limitations of the Study

The limitations of this study may have prevented other critical factors from being revealed. For instance, it was not possible to determine whether the costs of the cross-training program compared to revenue and savings. Nor was it possible to determine if the safety training for positions within the cross-training programs was too much for a worker on job rotation to remember.

It is also important to note that Peace River Pulp is not a unionized manufacturing facility. Therefore, this study may not have revealed some critical factors that must be dealt with when developing an effective cross-training program in a unionized environment. This reiterates the fact that each company is unique and therefore requires a unique cross-training program (Upton 1995), as is evident in the fact that the resistance displayed by operations employees proved to be beneficial, despite what was mentioned in the literature. Peace River Pulp simply designed its cross-training program to maximize the value of this anomaly.

References

- Adler, P. 1986. New technologies, new skills. *California Management Review* 29:9-28.
- Aoki, M. 1986. Horizontal versus vertical information structure of the firm. *American Economic Review* 76:971-83.
- . 1988. *Information, incentives, and bargaining in the Japanese economy*. Cambridge: Cambridge University Press.

- Brusco, M.J., and T.R. Johns. 1988. Staffing a multiskilled workforce with varying levels of productivity: An analysis of cross-training policies. *Decision Sciences* 29: 499-515.
- Cappelli, P., and N. Rogovsky. 1994. New work systems and skill requirements. *International Labour Review* 133(2):205-20.
- Carmichael, H.L., and W.B. MacLeod. 1993. Multiskilling, technical change, and the Japanese firm. *The Economic Journal* 103:142-60.
- Celani, A., and C.L. Weber. 1999. *Pay-for-knowledge: Guidelines for practice*. Kingston, ON: IRC Press, Industrial Relations Centre, Queen's University.
- Cordery, J.L., W.S. Mueller, and P.P. Sevastos. 1992. Multiskilling in practice: Lessons from a mineral processing firm. *Journal of Industrial Relations* 35(6):268-83.
- Dunphy, D., and B. Bryant. 1996. Teams: Panaceas or prescriptions for improved performance? *Human Relations* 49(5):677-99.
- Felan III, J.T., T.D. Fry, and P.R. Philpoom. 1993. Labour flexibility and staffing levels in a dual-resource constrained job shop. *International Journal of Production Research* 31: 2487-2506.
- Gittleman, M., M. Horrigan, and M. Joyce. 1998. Flexible workplace practices: Evidence from a nationally representative survey. *Industrial and Labour Relations Review* 52:99-115.
- Klein, G.D. 1998. A pay-for-knowledge compensation program program that works. *Compensation and Benefits Review*, March-April, 75.
- Knights, D., and D. McCabe. 1998. What happens when the phone goes wild? Staff, stress and spaces for escape in a BPR telephone banking regime. *Journal of Management Studies* 35:163-94.
- Lee, D.J. 1981. Skill, craft, and class: A theoretical critique and a critical case. *Sociology* 15:56-75.
- Mehaut, P. 1988. New firms' training policies and changes in the wage-earning relationship. *Labour and Society* 13:443-56.
- Park, P.S. 1991. The examination of worker cross-training in a dual resource constrained job shop. *European Journal of Operational Research* 51:291-9.
- Rinehart, J., C. Huxley, and D. Robertson. 1997. *Just another car factory? Lean production and its discontents*. New York: Cornell University Press.
- Schuler, R.S., S.P. Galante, and S.E. Jackson 1987. Matching effective HR practices with competitive strategy. *Personnel*, September, 18-26.
- Stanislaw, H., B. Hekseth, S. Kanavaros, T. Hekseth, and K. Robinson. 1994. A note on the quantification of computer programming skill. *International Journal of Human-Computer Studies* 41:351-62.
- Upton, D.M. 1995. What really makes factories flexible? *Harvard Business Review* 73.
- Vallas, S.P., and J.P. Beck. 1996. The transformation of work revisited: The limits of flexibility in American manufacturing. *Social Problems*43:336-61.
- Weber, C.L., and A. Verma. 1999. Flexibility, innovation, and the performance of Canadian establishments: Results from the WES pilot data. *Canadian Business Economics*. Forthcoming.