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著者	KOIKE Kazuo
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WORKERS SKILLS ON THE SHOP FLOOR AND GOVERNMENT ROLE

Kazuo KOIKE
Professor
Faculty of Business Administration
Hosei University

1. INTRODUCTION

This paper has two purposes. The main purpose is to disclose the character of workers' skill that is crucial in raising the competitive strength of an economy. Efficiency could differ largely due to differences in the levels of workers' skills, even though similar equipment and machinery are being used. According to a series of intensive field studies of contemporary Japanese industry, it is intellectual skills that promote competitiveness most (Koike & Inoki, 1990, Aichi-ken, 1987, Muramatsu, 1996). This paper aims to disclose the essential character of intellectual skills, how such skills can be built up and their prospects under the development of information technology and robotization. Most of the examples referred to here have been obtained from the results of a study on workshops in Toyota and its related firms, conducted in 1998 (Koike et al., 2001). In addition, a case concerning professional workers is also analyzed, utilizing the results of an international comparative survey (JIL, 1998). The other purpose is to examine the government role to promote and develop this vital skill of workers.

One feature of this paper is that the research results are analyzed and the conclusions are reached qualitatively, not quantitatively. As far as I know, no attempt to measure the level of workers' skills quantitatively in the field of economics has been successful. The implications of using a qualitative analysis to disclose the importance of intellectual skills are first to reveal the character of workers' skills through collecting and analyzing significant examples in which skills are being well utilized on the shop floor, and then to surmise comparatively the situation where these crucial skills are lacking. This could be an effective method to estimate the influence of workers' skills on productivity if we could analyze the essential components of intellectual skills in detail and depth. Through this approach, emerge the most vital workers' skills which make up the know-how to deal with uncertainty on the shop floor.

A crucial issue is to be addressed: the impact of robotization and information technology on workers' skills. One popular issue is the debate over whether or not robotization or developments in information technology may depreciate workers' skills. Since the Toyota study investigates also those workshops which largely utilize robots and information technology, this paper tries to answer this question by referring to a couple of cases in the study. We begin with dealing with production workers, though the theory obtained could be more applicable to the professional workers.

2. DEALING WITH PROBLEMS

Identifying Defective Products

Workers' intellectual skills are the know-how for dealing with uncertainty on the shop floor. Uncertainty on the shop floor consists of problems and changes in operations. The definition of "problems" implies those issues which are not fully known beforehand in terms of their content, when they might occur and their size. The most evident example of a problem is a defect in product quality. We cannot predict exactly what kind of defects would occur, their timing and how crucial they are for productivity. If we had been able to predict beforehand accurately, then we could have designed a computer program to identify and to handle product defects efficiently.

Changes are also uncertain in their extent and timing, although their character is determined. An obvious example is a change in output. The demand for products often changes, almost unexpectedly, in both timing and degree. If production workshops cannot effectively adjust to a change in demand, many unsold cars would accumulate in the stockyard, which would not only be an additional cost, but would also waste scarce resources.

Let me explain the skills required for identifying defective products in more detail. The know-how to deal with problems is composed of, first, finding and identifying the defective products in the operational flow. On an assembly line in the car industry, for example, the most visible defects are incorrect parts being attached or required parts not being attached. Although these are simple defects, they are not easy to identify during the usual flow of operations, since the cycle time, or process time, of an operation is as short as around 60 seconds in ordinary situations. (The cycle time becomes longer when markets are slack, as will be seen later.) Within a short period of only 60 seconds, it is not easy for workers to find out those defects that occurred earlier or during their own jobs, since workers have to carry out usual operations in addition to identifying defects.

It may be argued that inspection staff can fulfill this role better than the operators on the assembly line, who are busy conducting their own operations. Considering two very crucial points, however, an inspection may be far more costly than the defect being recognized by the assembly-line workers. One point is quite simple to explain: a defect becomes excessively difficult to identify later on the assembly line, because many parts that have been attached afterwards conceal the original defect.

Even when the defect is identified during later production stages, rectifying it requires far more time and hence increases costs. The simplest defects, such as incorrect parts being attached, for example, usually necessitate a lot of operations to replace the defective part with the correct one, because many parts that have been assembled after the original defect was made have to be dissolved or overhauled. The consequent damage to productivity is enormous. Thus, it is almost imperative to find the defects in the very jobs next to the one that caused the defect or, at the latest, during the last job of the workshop where the defect occurred. [(1)]

The best way to acquire the know-how for identifying incorrect parts or missing parts is, according to the statements of workshop supervisors and veteran workers, to have had experience in working on the preceding assembly-line jobs in the workshop. The reason is clear: to identify the defect in such a short time as 60 seconds, knowledge of the normal situation without any defect is indispensable. If an assembly-line worker has this knowledge, a glance is enough to identify something being incorrect. Experience in the subsequent jobs also significantly promotes a worker's capability to inspect for defects. While an operator is carrying out the subsequent jobs in the workshop, he or she becomes more aware of what points in the operations should be paid careful attention to in order to decrease defects, and when the worker is deployed in the preceding jobs with this experience, minimum defects naturally follow. Here, the important measure to acquire the know-how to deal with defects is that workers should have broad work experience covering most jobs in one workshop.

Identifying Causes of Defects

Identifying the causes of defects is more crucial to productivity than the case referred to above. Without this know-how, defects could repeatedly occur. If the causes of defects are not identified and accordingly not rectified, machinery continues to produce defective products; and if operators stop machinery for fear of producing many defective parts, production naturally is halted. In contrast, when the operator can identify the causes of the defects and rectify them, the machinery no longer produces the defective parts. The difference in productivity is remarkable.

This know-how requires a higher level of knowledge than simply recognizing that there is a defect. In order to work out the causes of defects, it is necessary to know the machinery structure and the production mechanisms, because any trouble in the machinery or in the flow of production may cause defects. Without knowing the machinery structure and production process, no one would be able to identify the causes of defects. And this knowledge becomes the more demanding, as the machinery structure and the flow of production become more complicated with the use of information technology and robots.

An example from another assembly-line workshop fully equipped with many robots may serve to illustrate the perspective when robotization develops. This is a workshop in one of the largest part suppliers in the Toyota group. 16 workers under one foreman are engaged over two shifts in assembling small electric motors, with almost two-dozen robots. Automatic machinery and robots carry out most of the assembly work, and the only remaining operations for the workers are dealing with problems. Dealing with changes in products is not so demanding here, since robots automatically handle change in products; censoring the bar codes on products instructs certain products to pass through a specific robot, and the others to be assembled by the robot. When a machine or robot finds something wrong, the machinery stops and a sign lights up to call an operator.

Here, the ability to deal with equipment such as robots is vital in handling defective products. Since assembling itself is almost all done by machines and robots, most defects are due to some kind of equipment trouble. Take, for example, a trouble in this workshop where products do not flow smoothly at a certain spot. Immediately after the worker in charge of that job has become aware of the slower flow, he tries to identify the cause. It is the practice of this workshop that the worker on the assembly line first tries to identify the cause, and if feasible, to rectify it before maintenance people have arrived at the spot. As it takes around 15 minutes for the maintenance people to come, the ability of workers to handle problems greatly contributes to efficiency.

Yet, a very high level of skills is naturally required for handling problems. In order to identify the cause, deep knowledge covering both the mechanical and electrical dimensions of equipment is needed, since a lot of variables may cause trouble. To take the above example, the slow product flow may be due to trouble on the mechanical side, such as a screw not being straight because of insufficient tightening, which prevents products from passing the censor, or to trouble in the censor itself or to something else.

The other reason why a high level of skills is required is a lack of full standardization in handling problems that differ one by one in their character and hence in their causes. Even robots made by the same manufacturer could vary with respect to the problems that frequently occur. Thus, the history of trouble for an individual machine or robot is extremely helpful for identifying the causes of problems. In this workshop, if the worker finds that the problem is too difficult for him to deal with in five or ten minutes, he calls for the relief man in the workshop, who is regarded as the most capable in handling problems. The relief man identifies the cause that the palette conveying the products stops at the incorrect spot, so that the censor cannot correctly react, resulting in the slower flow of products.

Workers are the first to handle robots. When trouble occurs and minute adjustments are required, it is now mostly the workers in the production workshop, rather than the maintenance people, who take care of this. This division of labor was also new even in this workshop, where the ordinary division of labor in which maintenance people played the main role in dealing with problems had prevailed 10 years before. The major reason for the change, according to the foreman and the relief men in the workshop, was that adjustments require knowledge of specific kinds of products and specific procedures of operations on the assembly line. Without knowing the character of operations accurately, such as whether strict screw tightening is imperative or not at a certain spot, minute adjustments are not feasible. Though the maintenance people have a greater knowledge of robots, they are not so good at knowing the specific forms of products and the specific assembly operations. It is the workers in the production workshop that have, through participating in handling problems, acquired specific knowledge of the structure of robots and machines.

3. DEALING WITH CHANGES

Changes in Output

Intellectual skills have to deal with the following four kinds of change: a quantitative change in output, a change in production methods, a change in products and a change in labor mix. Demand for products sometimes changes significantly. If production does not sufficiently adjust to the quantitative change in demand, the firm's profits will surely be damaged. Yet, efficient adjustment on the shop floor is difficult, unless the workers have acquired the two components of high skills required for making adjustments: namely, many of them being capable of doing most operations in the workshop, and some being so skillful that a redistribution of the operations into each job in the workshop is feasible.

The redistribution process is a famous part of Toyota Systems, which has now been diffused widely into other industries. When demand decreases by 20%, for example, Toyota decreases the speed of production by 20%, from, say, 60 sec. to 72 sec. for making one unit of car. (If the extent of change is smaller than 10%, an adjustment in working hours would be enough to accommodate the change.) A simple slow-down in the speed of the manufacturing line results in an increase in costs. To prevent this cost increase Toyota naturally tries to reduce the number of workers in a workshop by 20%, say from 15 persons to 12. Yet, no decrease in the kinds of operations should be made; if so, cars without doors, for example, could appear. Suppose there have been 60 operations in the workshop carried out by 15 workers before and which now have to be done by 12 workers. This cannot be implemented unless there are many workers who can conduct many different operations in the workshop. Redistribution would not be feasible simply by adding 20% more operations to each individual worker, because each operation differs in length of time required and in difficulty, and changes in the order of operations to be handled is unavoidable. Thus, the content of intellectual skills is, in this case, a capability of doing many jobs in the workshop.

The more demanding element of know-how to deal with this change is the one required to conduct a redistribution of the operations, which needs two components of knowledge. One is to know well the features of all the operations in the workshop: how difficult or easy they are, and what the order should be for assembling. Another is to know the skill levels of individual members in the workshop: who can currently conduct these operations. The best people with this knowledge are undoubtedly the veteran members of the workshop, since without having worked together there would be no opportunity afforded to know individual skill levels. This observation is a highly typical example of Hayek's "specific knowledge". If, instead, an engineer were to conduct the redistribution, the result would definitely be worse, since the engineer lacks sufficient knowledge due to not having worked together with the workshop members on a daily basis.

Changes in Production Methods

Although a change in production methods is less frequent than the above, its handling requires the most demanding skills. While a change in output occurs several times a year, a change in production methods appears once in about every two years, when new car models are introduced.

Two skills are required for handling this change: designing the procedures for manufacturing or for individual job content and having a voice in deployment or even in selecting machinery or equipment. A new car model necessitates a redeployment of the production process, in terms of both the mechanical side and workers' operations. To implement a new production process, Toyota organizes a small team consisting of veteran workers, each one from every two or three workshops, along with department engineers, for a preparation period as long as one year. During this period, the members of the team search for the best selection of equipment, best deployment of machinery and best design of operational procedures.

Apart from selecting equipment, the blue-collar team members seem to have a significant voice concerning various items, because it is they who know most about how to deploy machinery in the best way and how to design operations through their daily work. Letting blue-collar workers have a large voice in deciding these matters, unlike in any textbook lessons, is the most significant contribution of Toyota Systems. Without this voice, it is clear that a less efficient manufacturing process would have governed for a long time.

For workers to acquire this high level of knowledge, it is essential that they should experience the adjacent workshops that are closely related in the character of skills required. The section chief or the sub-section chief has a deliberate policy of moving capable candidates to the adjacent workshops. These promising workers are required to obtain the skill levels which enable them to identify the causes of problems in a couple of workshops.

Changes in Products and Labor Mix

The other two kinds of change do not demand such a high level of skills as the two former. One is a change in the kinds of product. The variety of consumer demand and its changes require one assembly line to accommodate various kinds of products. While small changes in the kind of product need few jig or tool changes, other changes require workers to change jigs and tools, which sometimes necessitate far higher skills than usual operations. When skilled workers change jigs and tools, not only can they do the exchange quickly, but also defective products rarely follow, since minute adjustments are usually crucial during the change. This feature constitutes another component of intellectual skills.

The last component of intellectual skills is the ability to deal with changes in labor mix. Two cases are illustrative. One is a need to substitute for absent workers in the workshop. On a continuous assembly line, even one vacant position stops the whole line. Consequently, it is imperative to have workers who can substitute for many positions in the workshop. This necessity is of course common to any assembly line in any country. In the USA, these substitutes, called relief men or utility men, are paid at a slightly higher rate than the others in the workshop.

The other case is the need to teach less experienced workers in the workshop. It is common that a workshop has newcomers to replace those who have quit or retired. Workers need instruction to become accustomed to even the easiest jobs in the workshop and, thus, veteran workers who can instruct them are required. The capability to teach newcomers is an element of workers' intellectual skills.

Four Levels of Workers' skills

To sum up, two crucial elements have emerged from the above analysis: the breadth of work experience and handling problems. By utilizing these two aspects, four skill levels even for car assembly-line workers who demand seemingly least skills can be identified.

Level 1 workers can carry out only the usual operations of one job, without delay and without paying any attention to defects. Two groups of workers belong to this level: beginners working for the car manufacturer, and temporary workers preferring short-term employment.

Level 2 regular workers with two or three years of experience can conduct two or three jobs in the workshop, at the level of identifying defects and placing a red tape to indicate the defective spot. The rapid flow of production or insufficient skills do not allow them to rectify defects.

Level 3 workers with their broad experience covering most jobs in the workshop can not only identify defects but also understand their causes. They rectify the causes of defects if they have time, so that no recurrence of defects would be expected in the flow of production.

Level 4 workers with their broad experience extending even to the adjacent workshops can design new operational procedures as well as deployment of equipment. They can also be the instructors in overseas plants.

Level 3 and Level 4 workers differ little in the skills utilized within one workshop; no variance exists in how they deal with problems and changes. Hence, both groups have intellectual skills, though they differ outside the workshop, as the latter have skills appropriate to overseas plants or to preparation for new car models.

Distribution of Four Skill Levels

The analysis so far has shown that intellectual skills can promote competitive strength remarkably. Yet, it has not been made clear how many workers with intellectual skills are needed in the workshop in order to elevate competitiveness. If only a few Level 3 and 4 workers are required, the fostering of intellectual skills may not be so crucial.

A step towards estimating the necessary extent of workers' intellectual skills is to identify the current distribution by four skill levels. The Toyota study discloses this aspect for nearly two-dozen workshops, covering various occupations of blue-collar workers. It is natural that die-making, or maintenance workshops consist mostly of Level 3 and 4 workers, with a few still in their training period. Yet, the focus here is on those assembly-line workshops which seemingly least need a high level of skills.

The Toyota study of 1998 shows that in an ordinary assembly-line workshop Level 3 and 4 workers account for nearly 50-60% of the total, while Level 2 constitutes 20-30%, and Level 1 also 20%. This distribution has to be examined to determine whether or not there is over-investment in human capital, since the survey year was at a time of slack labor markets that might have resulted in there being an overweight of workers with high skill levels. Truly in that year no temporary workers actually worked in the workshop. Instead, temporary transfers of regular workers from other workshops made up nearly 20% of the composition of workers.

Since no experimental investigation is available, a feasible measure for approaching the issue is to surmise the incidence when this distribution varies. Two constraints guide this conjecture. First, considering the character of skills, it is safe to say that the ratio of Level 1 workers cannot exceed a minority. As seen above, Level 1 workers cannot pay due attention to any defect that might be produced; and if a defect is overlooked, the cost of identifying and rectifying this defect on the final part of the assembly line becomes considerable, because many parts that have been attached after the defect occurred need to be dissolved first. To prevent this large cost being incurred, it is crucial to assign each veteran worker to a position immediately after the job being done by a Level 1 worker, so that any defect caused by the Level 1 worker could be identified without delay. And, not all jobs in the assembly-line workshop are appropriate for Level 1 workers. Even seemingly easy jobs require a high level of skills such as how to identify any uneven surface or any gap between doors and pillars. If inexperienced workers were assigned to these jobs, a series of defects would almost certainly follow.

Second, the skills of veteran workers of Level 3 or 4 cannot be developed instantly; it needs time to build up their skills; Level 2 is an indispensable step before a worker reaches Level 3 and 4. Taking all these constraints into account, the percentage of Level 3 and 4 workers may amount to 50 or 60%, which roughly coincides with the figures seen above of the current distribution and so denies the possibility of over-investment.

The percentage of Level 4 workers would be determined by two factors: the ratio of overseas plants to domestic in term of employment and the frequency of model changes. Currently, the overseas ratio for Toyota's total employment is roughly three quarters and it will definitely increase. Taking into account other factors relevant such as few instructors being able to stay in overseas plant forever, one Japanese blue-collar instructor being in charge of three or four workshops in an overseas plant, and in particular the current frequency of model changes, the weight of Level 4 would be no less than 10%. To my surprise, the Toyota study found not a few workers in the workshop who had never been instructors in overseas plants. A word of caution: the above story is confined only to blue-collar workers; engineers constitute another large part of overseas staff.

According to other in-depth studies in various industries, this high distribution of intellectual skills is not confined to Toyota and its relevant group, but is diffused widely to many workshops in large firms in contemporary Japanese industry. Yet, it should not be misunderstood that these high levels characterize most workshops in Japan. The smaller the firm, the lower becomes the percentage of workers with intellectual skills. A rough estimation would be that those workshops with many highly skilled workers would be in a minority.

4. IMPACT OF TECHNOLOGICAL DEVELOPMENT

Robotization

A question may naturally be raised: whether this ratio will increase or decrease because of intensive robotization or the development of information technology. An appropriate way to respond to this question is to investigate those workshops which are highly robotized or largely equipped with information technology. The Toyota survey includes another assembly-line workshop that is fully robotized, and a die-making workshop fully utilizing computer-aided design and manufacturing (CAD/CAM).

The workshop fully equipped with robots is almost equal in the distribution of workers' skill levels to the ordinary assembly-line workshop observed above. At a glance, this sounds odd, since in the workshop full of robots it is clear that the major operations required are dealing with problems, while regular operations are given to robots. Therefore, why does the distribution resemble that of the assembly-line workshop?

It is true that robotization means that the main-line work assignments are concentrated only on those workers with intellectual skills. In the peripheral jobs, such as distributing materials or packaging, workers with lower level skills are deployed, as temporary workers or inexperienced regular workers. The latter are expected to learn the main-line work; when the main line stops due to some trouble, they work as ad hoc manual helpers on the main line, which is a good opportunity for them to learn the work. So far as the main-line work is concerned, intensive robotization undoubtedly enlarges the weight of those workers with intellectual skills. The reason is evident. Now that the repetitive operations are wholly in the hands of robots, problem handling is left the hands of workers. Therefore, it would be hardly feasible for those workers without intellectual skills to conduct the main-line work.

Die-Making Workshop

Another indicative case is a workshop for fitting and erecting complicated dies. Needless to say, die-making, utilizing dexterous hand-grinding tools, is one of the most demanding jobs in the traditional sense of skills required. Yet, the character of the skills required has largely changed from an extremely high level of manual dexterity to a more intellectual one.

A change towards more intellectual skills is particularly recognized in two senses. First, the intellectual component of skills that has been included in traditional skills becomes more important, while manual dexterity contracts in importance. The introduction of extremely accurate machine tools with electric discharge along with the usage of CAM remarkably decreases the need for manual dexterity in fitting and erecting. This observation should never imply that dexterous fitting or proficient machine-tool operations disappear. Articulate adjustment of programming in CAM constitutes an increasingly important part of the skills of machine-tool operators. Yet, the operations that need dexterous fitting have largely decreased.

A remarkable example of this first sense is the know-how to have a voice in designing dies. In Toyota plants, when design engineers describe the framework of new dies, there is an opportunity for the veteran blue-collar workers to comment on the new design. They could say that this concept of die design is not appropriate since many problems could be expected when processed in manufacturing, or that this design might cause defects as "burri" or unnecessary fringes, whose correction needs much additional work.

Interestingly, the design engineers, who mostly have graduate degrees from prestigious universities, listened carefully to the comments of the veteran blue-collar workers. It is the blue-collar workers who know most about how to manufacture dies, rather than the capable design engineers. Yet, this attitude could never be maintained unless the opinion of the blue-collar workers turned out to be valid, which is easily tested through the actual manufacturing process. The blue-collar workers have to have an in-depth understanding of the die structure, practical knowledge and also experience both of manufacturing dies and of the problems that arose when dies were utilized for production.

An example of the skill component in the second sense is experience in the numerical design process by the production workers who have been engaged in fitting. As has been repeatedly emphasized so far, reasoning and identifying the causes of defects is central to workers' intellectual skills. As information technology progresses, this reasoning capability is required to extend to the sphere of information technology, as is clearly indicated by the case of a production worker in the die-fitting workshop. The designing process that naturally utilizes CAD is divided into two phases: the conceptual stage of design and the numerical stage of design. The former is responsible for the structure of dies, in which the veteran blue-collar workers have a voice. The latter stage that is relevant here provides numerical figures in the design. A worker engaged in die fitting reasons correctly that a particular defect in fitting is due to some miscalculation in the numerical design process. This reasoning would not be available unless he has worked in numerical design process for a while. Although this observation includes currently only some of the workers in the workshop, those workers who have some knowledge of numerical design could be better at identifying the cause of defects in die making. This type of career extension had never been conceived before information technology prevailed.

All these stories clearly show that the skills required are becoming highly intellectual. Then, the question of prime importance arises of how to foster these intellectual skills. It may be imagined that, because the skills required are so intellectual, Japanese blue-collar workers are now tending to be college graduates. Almost the reverse is the case, as explained below.

5. FORMATION OF INTELLECTUAL SKILLS

Grade of Education

Most blue-collar workers in contemporary Japanese industry have 12 years of schooling.

Exceptionally, however, in Toyota and its group, there are two groups among those with 12 years of schooling. The main group is composed of workers who graduated from senior high school at the age of 18, which is no different from those in ordinary large firms. The Toyota feature lies in the other smaller group's members, who finished three years of full-time schooling, wholly sponsored by the company, after nine years of compulsory education.

These schools, fully sponsored by companies and usually called "trainee schools", had been common among many large firms in Japan during the period from World War 1 to the 1960s. The most famous examples are Hitachi, Nippon Steel and many other established companies. Since the middle of the 1960s, when most boys and girls proceeded to senior-high schools for better job opportunities, these trainee schools have been declining in number due to the difficulty of attracting boys with a high aptitude. Nowadays only a few companies maintain trainee schools, such as Toyota and its relevant group along with Hitachi. Yet, the percentage of trainee-school graduates to regular workers has been small. Most blue-collar workers discussed in this paper have 12 years of schooling with little technical training before entering Toyota. Thus, the core method of forming intellectual skills is principally broad and in-depth OJT (on-the-job training) on the shop floor, supplemented by short periods of OffJT (off-the-job training).

Broad, In-depth OJT

By broad OJT, we imply that a worker experiences most jobs in one workshop for as long a period as 10 to 15 years. The practical method adopted by these workshops in the Toyota study is not so-called regular rotation as is usually thought typical to Japanese systems. Instead, irregular rotation is more common. After one year or so on one job, workers would be asked to move to another job in the same workshop so as to enlarge their work experience. Around five years later there appear two groups of workers: one staying in a small number of jobs for a long time with the other continuing to move frequently. Moreover, later some members of the latter group move to other workshops which are closely related in technology, such as adjacent workshops on the same assembly line.

In order to make it possible for a worker to move to other jobs in the same workshop, a veteran worker, who is partly engaged in his own line job, usually works as an instructor. This instruction takes the following stages: first, the instructor shows the pattern of how to perform the job, next the trainee does his own job while being observed by the instructor, and third, the instructor goes back to his own job, while the trainee conducts the job by himself, asking the instructor questions only when the trainee has any problem. The period taken for the first two instruction stages is as short as several weeks. Yet, the third stage might last a long time, in particular when the instruction extends to the know-how for dealing with problems and changes. Through this broad OJT, the worker is exposed also to handling problems in that job. This is in-depth OJT through which intellectual skills are fostered. Exchanging information obtained through handling problems with fellow workers is another way of promoting intellectual skills.

Short OffJT

To develop the know-how to deal with problems it is necessary to acquire basic knowledge of the structure of products and of the theory of electricity or of machining. Without knowing the structure of a car, for example, it would be almost impossible to identify the cause of defects in cars. This knowledge is best acquired by short OffJT, mostly in-house in the case of large firms. These OffJT courses are well diffused among the members of the workshops in the Toyota study. Yet, it would be hard to say that OffJT plays a key role in forming these intellectual skills. It is basically because OffJT courses are appropriate for teaching those items that are standardized in handling; and so the content of OffJT courses is also standardized. As repeatedly emphasized, however, problems are not standardized in their character, timing and extent. Thus, it is hard for OffJT to play more than a supplementary role.

OffJT courses are usually as short as two days or so, inserted in-between OJT on the shop floor. Thus, we call them short, inserted OffJT. It should be noted that there are more OffJT courses for those workers in the workshop with intensive technology such as robotization; the courses are clearly more frequent and have more topics, so that in aggregate more time is devoted to OffJT. A simple conclusion could be drawn that the higher the technological development, the greater is the weight of OffJT courses (for more detail, see Koike, 1997).

Pay-for-Job-Grade

For fostering intellectual skills, appropriate incentive systems are indispensable. Appropriate incentives need to assess fairly the extent of skill development and to provide an appropriate reward. Yet assessing the development of intellectual skills is not easy and can hardly be done by looking at the single job in which a worker is currently deployed. Suppose there are two workers who are currently assigned to similar jobs in the same workshop. Also suppose one of the two workers is capable of conducting almost all the jobs in the workshop and accordingly can substitute for absentees, instruct inexperienced workers and in particular can handle problems, while the other cannot do these operations, due to having had no experience in any other job in the workshop than the current one. Under pay-for-job systems these two workers are paid equally, so that no reward is paid to the one who can deal with problems. Pay-for-job systems are not appropriate for forming intellectual skills. Pay-for-job-grade systems that can evaluate problem handling and the breadth of experience are urgently needed.

Pay-for-job-grade systems should have four vital features: job grade systems, range rate, yearly increments and merit rating. These features work extremely well in fostering intellectual skills. First, job grades can reflect the level of intellectual skill by considering the breadth of experience or problem handling, instead of just the single job in which the worker is currently deployed. Second, the range rate can accommodate skill development while a worker stays on one job, which is commonly recognized to occur particularly for the initial three years or so on a job. For example, an industrial-relations manager is much more skillful in dealing with labour unions in the third year than in the first year. If this skill development is not assessed, few are encouraged to develop their skills on the job. Third, performance appraisal is necessary for assessing the individual level of skill development. When a high level of skill is required, naturally differentials by individual emerge in the levels attained. Without assessing and rewarding this differential, few would make the hard effort required to elevate skills. Fourth, the long term is needed for forming intellectual skills, since broad experience, the essential part of intellectual skills, necessarily takes time. We need to encourage workers to stay in the company for a long period. Regular yearly increments in pay are clearly an effective incentive.

Pay-for-job-grade systems with these four features prevail for both blue-collar and white-collar workers in large firms in contemporary Japan. At a glance this statement may sounds curious when we remember the popular opinion that Japanese pay systems are largely based on seniority. Since this issue is discussed in detail elsewhere (Koike, 1994), just a few words are enough here. Although it is true that pay systems for workers in large firms are seemingly composed of various components other than the pay-for-job-grade, an in-depth study has revealed that the main part of these various components is in practice decided by the job grade.

All these four features for Japanese blue-collar workers in large firms are characteristic of ordinary pay systems for professional workers in large corporations in Western Europe and the USA. This implies that blue-collar workers in contemporary large Japanese corporations are paid with practically similar pay systems to those for professional workers in the West. In other words, this is "white-collarization" of the blue-collar workers, as discussed in Koike (1988). The story outlined above is just one part of this white-collarization.

6. APPLICABILITY TO WHITE-COLLAR WORKERS

Components of Necessary Skills

Though this paper has so far explained the case only for the production workshop, its content is even more applicable to professional workers in industry, because they are fully exposed to problems of uncertainty. Here again an analysis of a case would be insightful. A case of professional workers in charge of budget control of a subdivision in a large manufacturer is examined as a typical job of college graduates with nearly ten years of accounting experience (JIL, 1998, Ch. 4, pp. 82-84).

This job has two main parts: compilation of the budget every six months and its administration afterwards. Controlling the administration of the budget demands far higher skills than its compilation according to the statement of our interviewees, although that too is demanding. The difficulty lies in determining the causes of the gap between the budget and the monthly performance. If these causes could be correctly identified, the possibility of remedying the trouble could be at hand and the next budget might thus become more efficient; if not, the prospect of making an efficient budget for the next term is unlikely. The difference is enormous.

Discovering the causes is composed of many components because there can be many diverse reasons for the gap between the budget and the monthly performance. First, trouble in the manufacturing process alone could be a cause enough. If the accounting staff are skillful in identifying such a cause and, accordingly, the prospect of remedying the trouble, the next budget can already become more accurate. Discovering which part in the manufacturing process is in trouble, what the character of the trouble is, whether this is likely to frequently be repeated or not, what measures are appropriate as a remedy, and how long a remedy would take, are the main items to be determined. Thus, knowledge of the manufacturing process is one of the major components is the skills necessary for accounting staff in charge of budget control.

Second, knowledge of the organization is indispensable. Trouble is not confined to machinery but can come out of the organization: miscommunication among the people who operate the machinery, for example, can cause the gap. For such a cause staff would need to identify many factors, including what part of the organization suffered from miscommunication, what measures can be mobilized for solving that trouble, and what the consequences to the next budget would be.

Third, factors outside the firm also need to be taken into account. Changes in demand, for example, heavily affect cost and therefore the gap. If a change in the demand for semiconductors, either in the amount or the kind, exceeds what is expected, many measures need to be taken, including transferring workers from one line to another so as to accommodate the required change in production. Such measures themselves increase the cost and hence produce some gap, resulting in enormous differentials in efficiency. Forecasting changes in markets accurately is almost impossible for anyone; so uncertainty is a constant factor. Such innate uncertainty is increased by the large variety of semi conductors and the fact that they are often made to the specifications of the individual customers in accordance with the design of the production systems. In short, a lot of factors beside knowledge of accounting are required for the accounting staff to control the budget.

Starting from Cost Accounting at a Factory

Acquiring these skills requires OJT, beginning with the job of being in charge of cost control for one production line in a factory manufacturing semiconductors. This job consists of two parts: computing the standard manufacturing cost for each kind of semiconductors the manufacturing line produces, and analyzing the gap between the standard cost and the actual monthly cost. Similar to the problem of budget control, it is the analysis of the gap that demands far higher skills. For analyzing the gap, knowledge of various factors is indispensable. Trouble in the manufacturing process can be enough to produce the gap; the staff run round the manufacturing process to identify the cause of the gap. So can miscommunication and the change in the market, either in the amount and kind of products, be sought.

Thus, the skills needed to do a good job with cost control of one production line has a strong resemblance to those needed for budget control. All that is missing is knowledge of a broader span of products, of the manufacturing process, and of the overall organization. Career development is structured to compensate for this lack through broadening experience.

Clearly, beginners in accounting do not initially have all the skills required to conduct this role. A basic knowledge both of cost accounting and of accounting is indispensable, but those can be acquired by study at universities or other schools. This firm requires all the new recruits in accounting to acquire these skills by themselves; the recruits have to take and pass written exams at the third and fifth year at work on basic accounting and cost accounting.

Most of crucial components of the skills necessary, however, as knowledge of the manufacturing process, the organization, and the market, are almost impossible to teach at universities or schools since these are industry-specific or even partly from specific. What happens in practice is that the veteran workers in the accounting group in the factory instructs the beginners, who ask a lot of questions while searching for the causes of the gap.

After an initial year in charge of one manufacturing line, their breadth of experience extends to the neighboring line, to plural lines, and even to another factory that manufactures different semiconductors. After experiences like these for six or seven years, many accountants' staff are moved to one of the subdivisions in the semiconductor division. There they first handle budget control of the manufacturing account then of the sale account, and finally of all aspects of budget control for the subdivision. Then, they move to another subdivision in the same division, and finally they take over budget control for the whole division. These careers can be extended to financial accounting jobs or even finance, so that these accounting staff can work as financial directors in overseas business units or in administrating related companies. Thus, the broad single- functioned career can be obtained.

There may be other methods, such as OffJT course at universities or schools or at training institutes either in house or outside the firm, or other type of OJT moving across several firms. There could also be a mixture of the two, such as is required to obtain a formal qualification like the Chartered Accountant in the UK for example, that requires two or three years of experience in accounting firms. Yet those methods would be less efficient for acquiring the components of the skills required, considering the character of the necessary skills.

Understanding manufacturing process enough to identify the causes of problems, which is definitely the core of controlling the gap between the budget and the performance, requires broad experience and knowledge. It is almost impossible to acquire this at schools or OffJT courses in the institutions outside of the firm. And, it is difficult to provide fully the knowledge necessary to deal with uncertain problems that that might occur in OffJT. Thus, the methods to make necessary skills through a broad single function career described above can be said considerably efficient.

7. GOVERNMENT ROLE

Problems of Traditional Systems

All the arguments so far clearly suggest that the traditional methods of skill formation now face difficulty, particularly when we consider the character of work-based skills. By the traditional methods, we imply training institutions as well as learners systems (or apprenticeship in a classical word), both of which concentrate their training to the initial period of the workers careers, and are partly or largely sponsored by government either directly or indirectly through employers.

Take for example of contemporary Japanese systems. Nearly 300 training institutions scattered all over Japan have been fully sponsored both by Ministry of Labor and Local government, devoted in training beginners for initial one or two years. Yet, employers have been evidently reluctant to recruit from the graduates of these institutions, and prefer to follow the method described above in making necessary skills. Government also subsidizes training courses of occupational associations as well as craft unions; a most remarkable example is the one of builders union, the largest craft union in Japan. And these are mostly confined to the training courses for the initial stage of the workers career. To generalize this, a crucial problem in the traditional systems is that training is rather confined to the initial period of the occupational career. As seen above, intellectual skills to deal with problems and change need relatively a long time to build them, since making broad experience, the vital base of the skills, takes a certain period to build them.

Once work-based skills turn out vital, a new issue emerges; that is the difficulty in how to assess the skill grade of individual workers. This difficulty becomes the more because labor markets increase mobility in many countries. Information on the skill grade of individual workers, or on quality of work force in general, is most difficult to obtain outside the firm, and the work-based skills naturally make this difficulty the more. It has been frequently said that so-called professional standard can guarantees the quality of work force, if it is well established. Now that the professional standard is, as an intensive investigation reveals (Japan Institute of Labour, 1998), practically relevant mostly to the entry level, for the skilled occupation, this does not work well in assessing the individual skill level of high grade. It is a crucial issue how to obtain exact information of workers skills based on workplace experience.

Thus, in many industrialized countries as the US or the UK, a new role of government is requested; to make the national skill standards that serve to distribute information of individual workers skill level (Ashton, 2000). An example is National Skill Standard Act in the US, enacted in 1994. Yet, it is almost inevitable to suffer from a series of obstacles, once we remind of the character of the work-based skills. This system would be successful if this is limited to the lower level of skills. Once we try to include the high level of work-based skills to deal with problems and changes on the shop floor, however, it is not easy for government to establish the national skill standard. What is expected for government concerning national skill standards is to establish the framework in which those institutions relevant such as employers, trade unions, and representatives of individual workers by occupations or by industry interact and exchange information based on individual workplace experience.

Funding to Individual Workers

The above argument never implies that little role of government is expected. Rather, a new horizon could be developed, mainly on two aspects: money and information. So far money has largely been paid either to employers or to occupational associations including trade unions. Take for example again Japan, money collected as a part of employment insurance has been disbursed to assist single employers for in-house training or occupational associations as well as trade unions as builders. Since 1999, a part of that money can be paid directly to the individual workers, supporting their participation in OffJT courses that individual workers choose.

This voluntary choice by individual workers should be emphasized, in particular considering the very character of the work-based skills. As repeatedly emphasized so far, work-based skills have to deal with uncertainty. Almost by definition, this implies that it is the individual workers of intellectual skills who know most effective OffJT courses in making necessary skills at particular phases of skill development. Because the problems to be handled are something uncertain, it is hard for employers to exactly foresee and decide which OffJT courses are most effective. Thus, this funding directly to the individual workers supplied by government not through their current employers seems extremely important.

Making and Distributing Information

The OffJT course is, as seen above, supplementary in making work-based skills, however. It is OJT that is the core in making the intellectual skills, in which Government can hardly play the key role; OJT inevitably needs to be implemented on the shop floor. Yet, government can play an important role in implementing OJT. That is to distribute the very vital information, such as what type of career is effective for a certain occupations, to those firms and individual workers who are interested in human resource development. In other words, government, first, conducts intensive surveys on the workers careers by the main type of technology or by occupation and, second, to distribute this information to those who are relevant. Making and distributing information is one of the most important roles of contemporary government.

Even in implementation of career management, government can do something, as to build and supply consultation staff for individual firms that try to improve human resource development. It is because implementation of career making needs to be tailored according to the particular situation of individual firms or individual workshops; no simply standardized way can be effective. The staff that is of indepth and broad experience in dealing with various cases can be dispatched to individual firms for promoting the formation of work-based skills. Government can support for making these instructors and introduce them to individual firms that need this consultation. All these strategies stated above can be well applied to development assistance for developing countries by developed countries.

Note

(1) By workshop, we imply a unit of workers organized under one foreman, usually consisting of 10 to 30 people. The foreman is defined here as the lowest ranked supervisor, who is mostly working off line.

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Bibliography

Aichi-ken (1987) *Intellectual Skill Formation,* Aichi-ken, Rodo-bu (in Japanese).

Ashton, David (2000) "Skill recognition systems, the US, UK and European experience", paper presented to Regional Meeting on Workplace-based Skills Recognition and Training, OVTA, Chiba, Japan.

Japan Institute of Labour (1998) *Human Resource Development of Professional and Managerial Workers in Industry: An International Comparison*, Japan Institute of Labor.

Koike, Kazuo (1988) *Understanding Industrial Relations in Modern Japan*, Macmillan.

Koike, Kazuo (1994) "Learning and incentive systems in contemporary Japanese industry", in M. Aoki, & R. P. Dore eds., *The Japanese Firm,* Oxford Univ. Press.

Koike, Kazuo (1997) *Human Resource Development,* The Japan Institute of Labour.

Koike, Kazuo,(1998) "NUMMI and its prototype plant in Toyota", *Journal of the Japanese and International Economies*, no. 12.

Koike, Kazuo, & Takenori Inoki (1990) *Skill Formation in Japan and Southeast Asia*, Tokyo University Press.

Koike, Kazuo, Chuma Hiroyuki, & Ota Soiti (2001) *Monotukuri no Gino (Workers Skills in Manufacturing Industries),* Toyo Keizai, (in Japanese).

Muramatsu, Kuramitsu (1996) "Intellectual skills in mass production industry: Integrated systems vs. separated systems", *The Monthly Journal of the Japan Institute of Labour*, no. 434 (in Japanese).