HUMAN FACTORS IN ORGANIZATIONAL DESIGN AND MANAGEMENT – IV

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Development of Assembly Competence in Parallellized Flow Assembly Systems

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Abstract

This paper is based on an action research oriented case study of the Volvo Uddevalla final assembly plant. The paper initially contains an overview of the plant. The main focus is on data describing the assembly workers' assembly competence during full-scale production in this plant, i.e. for example, how the competence varied in the different product workshops and how variables such as age, period of employment and sex influenced this competence.

1. THE UDDEVALLA FINAL ASSEMBLY PLANT

The now closed (April 1993) Volvo final assembly plant in Uddevalla was situated some 90 km north of Gothenburg. It was designed for a one-shift production capacity of 40 000 cars per year, but due to the decrease in sales, full production capacity was never utilised. Only five of the six product workshops were used for production purposes. The sixth workshop was used as a training and development facility. Late in 1992, 708 blue-collar workers and 108 white-collar workers were employed at the plant. The age and sex distribution of blue-collar final assembly workers is shown in figure 1.

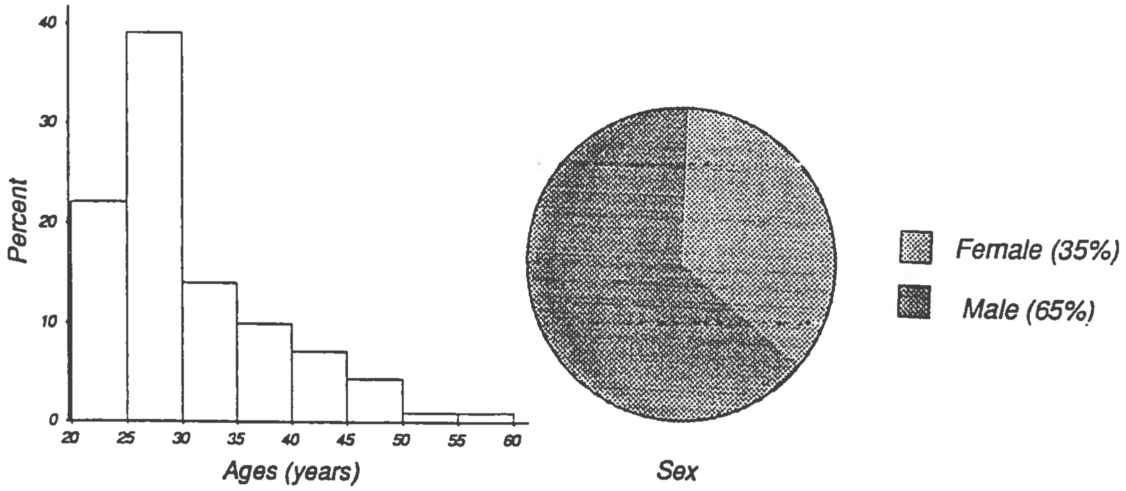

Figure 1 Distribution of age groups and sex of the blue-collar, final assembly workers at the Uddevalla plant during the closing down phase.

A stated aim of the personnel policy was that the number of employees of different ages and sex should reflect that of the Swedish labour market in general. In specific terms, the aims were 60% male workers and not less than 40% female workers as well as 25% workers younger than 25 years, 50% workers 25 – 45 years and 25% workers older than 45 years. This aim was not fully achieved, for example, there was an underrepresentation of older women.

2. A BRIEF SUMMARYZATION OF THE DESIGN ASSUMPTIONS AND DESIGN PROCESS

It has not generally been realised that what made the Uddevalla plant design pioneering was the simultaneous emphasis on technical preconditions and their social consequences.

In the Uddevalla plant, the material flow patterns, the materials feeding techniques and the information systems were technically designed so as to facilitate learning and development of knowledge. New training methods and materials handling equipment also supported competence development. This fundamental interplay between technology and the human being was vital during the design and running-in period. As anticipated, the plant design gives rise to positive social effects only hinted at in this paper.

Due to the labour shortage experienced when the plant was conceived, one of the original design criteria was to make assembly work more attractive. Extended work cycles as such were regarded as one means towards this goal. Extended work cycles, in turn, required increased operator competence. Initially, such competence development was, however, not seen as a means to attain higher productivity, since management was not aware of the fact that parallellized, long cycle assembly is inherently more efficient than serial, short cycle assembly due to reduced loss inefficiencies [1, 2].

The failure to understand this fact probably contributed to the decision to close down the Uddevalla plant, although the official reason for the decision was the sharp decline in sales experienced by Volvo.

As a consequence of the inherent technical structure of the plant, the work itself became meaningful with an extensive work content which could only be mastered by competent and skilled members of the organisation. This was due to the fact that a minimum cycle-time of 90 minutes was required to master the agreed production volume. Thus, traditional assembly line competence of 2 – 20 minutes was inadequate, because it would have required a total re-design of the plant. Consequently, suitable preconditions for competence growth on the shop floor thus became indispensable.

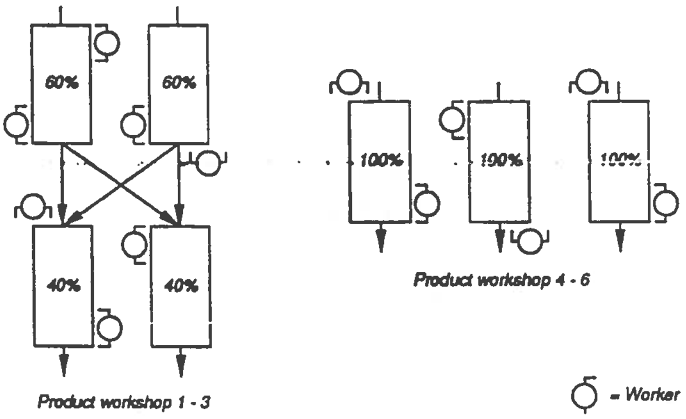

Figure 2. The layout of the different workshops in the Volvo Uddevalla final assembly plant. In workshops 4 – 6, the body was standing still at one internal work station during the whole assembly, while in 1 – 3 it was moved once. There were also other dissimilarities with regard to the location of the subassembly stations, assembly tools, etc.

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3. ASSEMBLY COMPETENCE IN THE DIFFERENT PRODUCT WORKSHOPS

Since there had been close cooperation between the Volvo Corporation and researchers during the design, running-in and full-scale operation periods 1985 – 92, we had the opportunity to compile a extensive documentation together with the employees at Uddevalla during the last three months of production.

This activity involved video-recording the assembly and materials handling work, handing out questionnaires regarding, for example, psychosocial factors and work environment, collecting almost all production technique documents and protocols, arranging them into an archive located at Chalmers University of Technology, etc. Today we have at our disposal an extensive data base by no means yet fully analysed.

As an example of analysis of this data, we have in figure 3 illustrated the assembly competence in the different product workshops. The diagram is based on wage-related personnel statistics, which divided the assembly work into four steps 29 – 40%, 40 – 60%, 60 – 80% and 80 – 100%, of an automobile. To summarize this data, 64% of the assembly workers learnt to assemble at least 60% of an automobile at full pace, and 4% were even able to assemble complete automobiles single-handedly at full pace, which they proved by permforming a special test.

Note that in this case, we only report on the competence according to how the worker mastered the extended work content. We have therefore called it "assembly competence". We do not consider other vital aspects of competence, some of which were included in the wage system, for example social competence in to recruiting and introducing new members to the work groups. In fact, the wage system was quite advanced and it was constantly being reviewed and debated during the plant's total life.

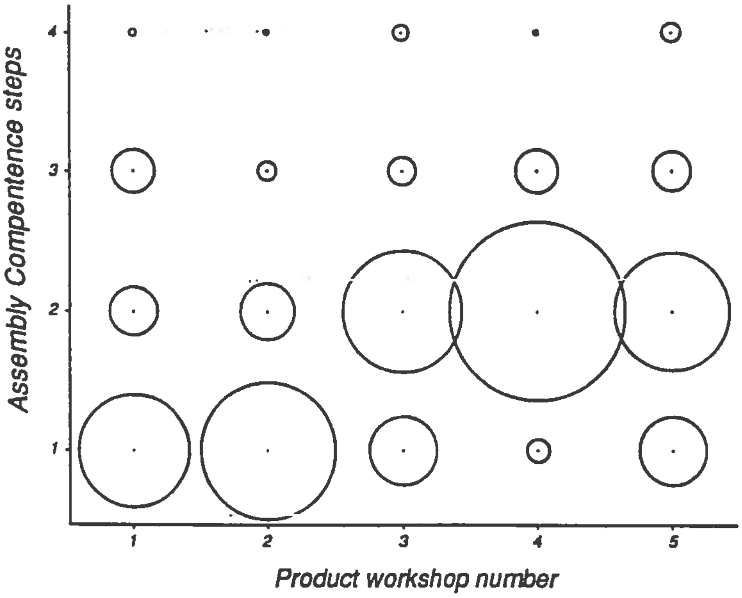

Figure 3. Distribution of blue-collar final assembly, worker competence in the different product workshops. Note that step 4 in the diagram equals the ability to assemble complete automobiles, i.e. 100%.

The high assembly competence in the plant may to a large extent depend on the prestructuring of the components needed for assembly in kitting fixtures, which formed complete kits of the materials required for one single automobile. The relationship between the vehicles being assembled and the kitting fixtures supported a holistic learning process. In such a process, an individual is said to have a holistic approach, i.e. he regards the learning material as a whole, and the constituent parts are seen in relation to this whole [3, 4].

The component kits implied a recommended work method suitable for various intra-group work patterns and work group sizes. The main principle being the possibility to choose different assembly methods, all such methods derived from the same basic work structuring [5]. At in the end of the plant life, there was a great variety of group sizes and intra-group work patterns. During the closing down phase, the work groups in the product workshop consisted of 2 – 9 assembly workers each.

Another vital factor for contibuting to the high assembly competence was the hectic and tough running-in period, which made it necessary, apart from learning to perform the assembly work itself, to add the verbal and social dimensions required to tackle the technical and social problems present during the whole running-in period.

As noted in figure 3, the highest competence was achieved in product workshops 4 – 5. According to our interviews, one main reason for this fact was the layout of these workshops but in some cases the mangement of the workshop deliberately choose to prioritize 29 – 40% competence due to more intensive training on this step. The proximity of the automobile bodies and their being stationary during the work is likely to have influenced the growth of assembly competence substantially. This will however require further analysis.

4. INFLUENCE OF AGE, PERIOD OF EMPLOYMENT AND SEX ON THE ASSEMBLY COMPETENCE.

In order to throw light on some aspects of competence we performed some brief statistical analyses of assembly compenetce based on period of employment and sex, see figures 4 – 6.

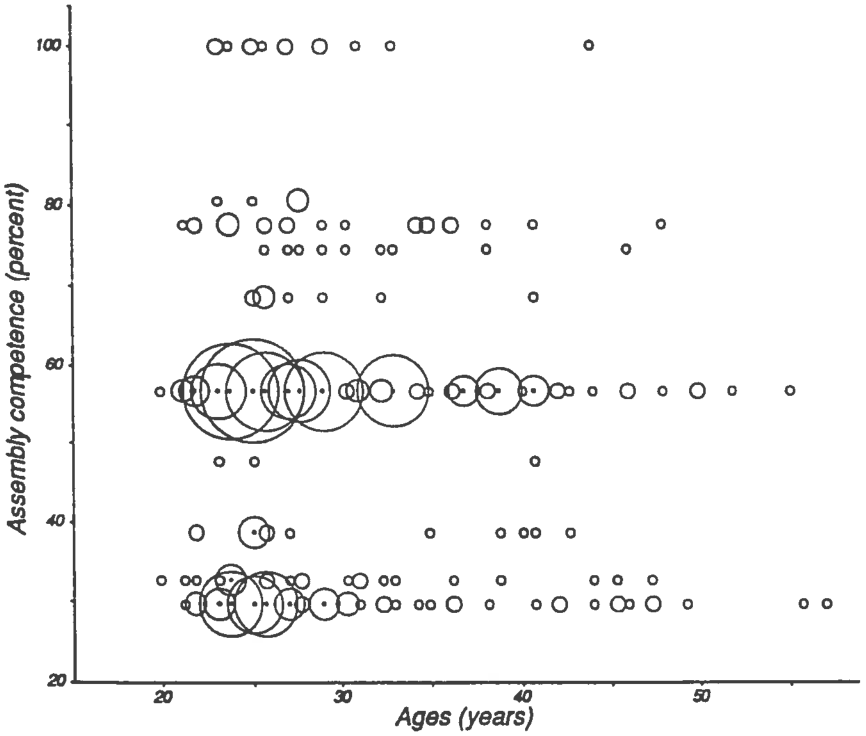

Figure 4. Distribution of assembly competence in relation to the age of the blue-collar final assembly workers. Note that 100% equals the ability to assemble complete automobiles.

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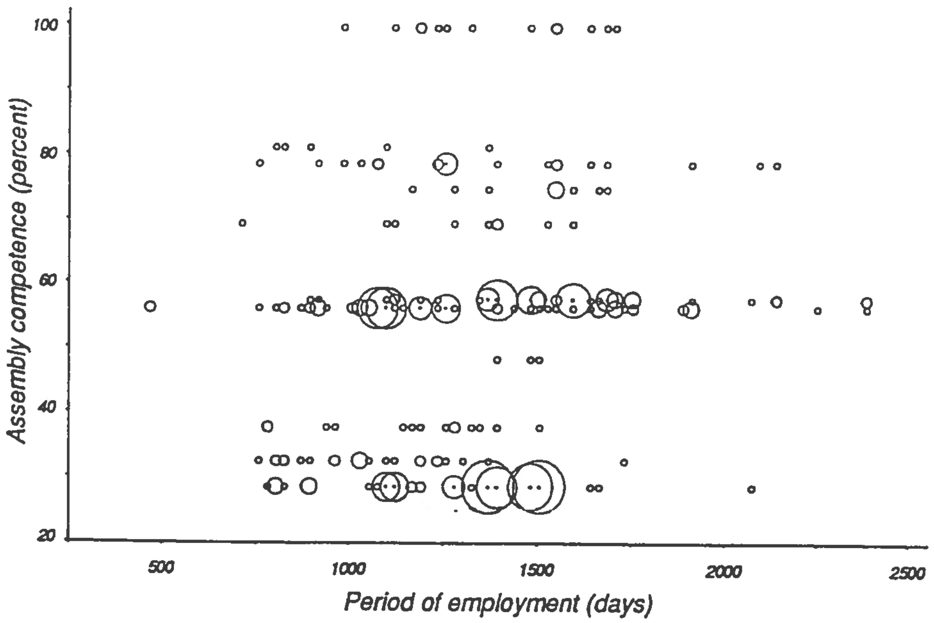

Figure 5. Distribution of assembly competence in relation the period of employment of the blue-collar final assembly worker. Note that 100% equals the ability to assemble complete automobiles.

Table 1. Distribution of assembly competence (comp.) in relation to the period of employment, sex and number of the blue-collar final assembly worker. Note that 100% equals the ability to assemble complete automobiles.

Period of employment (days)	400 – 1 200		1 200 – 2 000		2 000 – 2 800		Totals:	
	No.	Comp. (%)	No.	Comp. (%)	No.	Comp. (%)	No.	Comp. (%)
Male	89	50	92	59	5	60	186	55
Female	24	50	73	46	5	57	102	48
Totals:	113	50	165	53	10	58		

5. CONCLUSION

Assembly competence is dependent on product workshop and workshop layout (10% span of variation with regard to assembly competence). As noted in figures 4 – 6, age, period of employment and sex also have some influence (7% span of variation with regard to assembly competence). This is of course a simplification and further analysis is required, which ought to be possible on the bases of our extensive documentation of data from the plant.

This analysis is necessary due to the fact that, among other things, the management style, recruiting strategies, personel turnover, workgroup composition, etc. as well as productivity and quality performance, varied between the product workshops and during the total life of the plant.

Generally speaking, the data reported above underlines the potential of the production and learning principles practised. In fact, the experiences indicate that an economically feasible cycle time for automobile assembly to is a minimum of two hours instead of the generally accepted maximum of twenty minutes, provided that correct design and running-in procedures are applied.

The conclusion is that this type of assembly system does not need extremely long learning and training times. This contrasts with traditonal learning curves, e.g.[5], that describe how the time required to complete a work task, e.g. to assemble an object, decreases with the number of times the task has previously been performed.

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