A Work Study Technique for Non-Repetitive Work : Development, Reliability and Validity*

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The scientific management movement, begun in the 1880's, aims at " maximum prosperity for the employer and the employee at the same time " (5). The various techniques of scientific management consist of " systematic procedures of investigation, planning, or control which can be applied to all management problems of a given type, wherever they may occur " (5). Their objective is to provide the solution to the question : How can maximum productivity with existing resources be attained? Associated with the names of the pioneers of scientific management, Taylor and the Gilbreths, work-study is the chief technique employed to seek the answer to the above problem. It aims at increasing productivity through effective utilisation of human effort and reducing poorly utilized time, inefficient methods of production, and wastage due to defective designs. Work study principles have been applied in many areas and fields " as a means of raising the productive efficiency (productivity) of a factory or operating unit by the reorganisation of work " (5). By now work study is well-established in businesses and industries where repetitive work is predominant. It has also produced many improvements in some of the areas usually considered outside its domain *e.g.*, departmental stores, hospitals, hotels and mail-order houses (6). But the office has been slower to adopt such ideas. In recent years, a promising development has been the increasing attention to workstudy for office use (4).

Work study has been variously defined by different workers, but the definition, as given in an International Labour Office publication, " Introduction to Work Study " (5), states as follows :

> " Work study is a term used to embrace the techniques of method study and work-measurement which are employed to ensure the best possible use of human and material resources in carrying out a specified activity."

Again,

> " Method study is the systematic recording, analysis and critical examination of existing and proposed ways of doing work and the development and application of easier and more effective methods " ; and " Work measurement is the application of techniques designed to establish the work content of a specified task by determining the time required for carrying it out at a defined standard of performance by a qualified worker " (5).

Hence it may be said that work study is a technique of analysing production and work methods with a view to determining the time required to carry out a specified task in the easiest possible way of doing it, when the necessary steps are organised in the best order and unnecessary steps completely eliminated. Thus method study and work measurement are closely linked ; method study is concerned with the reduction of work content of the operation, while work measurement is concerned with the investigation and reduction of ineffective time, and the subsequent establishment of time standards on the basis of the work content established by method study.

Work study has been found useful for raising productive efficiency of an operating unit by the reorganisation of work without incurring any capital expenditure on the plant and equipment. It is considered to be one of the most accurate means of setting up standards of performance on which effective planning and control of production depend. It is also useful for better control of work scheduling and individual work assignments and enables effective budgeting, forecasting and planning. In addition, it can be used as a basis for personnel policies such as installation or revision of a job-evaluation plan, or preparation or rewriting of job-descriptions or balancing the work of members of teams or balancing workers with machines.

The process of work study consists of the following steps :

(*a*) Dividing the work of a man in small elementary operations.

(*b*) Recording from direct observation everything that happens, using the most appropriate recording techniques and noting the time required for each operation.

(*c*) Analysing the operations critically and developing the most economical method by eliminating useless operations, taking into account all the circumstances.

(*d*) Measuring the quantity of work involved in the method selected and calculating a standard time for its performance.

Work study techniques have been mainly applied to repetitive work in previous years. The techniques for analysing repetitive work have sufficed to date because repetitive work was the predominant type. However, no more work is becoming non-repetitive in nature. Automation and modern technological developments are bringing this in the form of more maintenance men, technicians, engineers, and research workers. Non-repetitive work is also associated with supervisory activities. Activities and operations such as those of foremen, purchasing agents, draftsmen, office clerks and office peons or helpers, and business executives are further examples of non-repetitive work (6).

In recent years, generally one of the three approaches was utilised for the analysis of non-repetitive work (1) :

(*a*) Place the observer with individual(a) doing non-repetitive work ; the observer records all the activities and the time for each activity as performed by one or more of them ;

(*b*) Operator records what he works ; the operator is provided with a form and is asked to report the time and description of each activity as and when he performs it.

(*c*) Work sampling (Occurrence study). It determines the percentage of time spent by the individual(s) on the various activities of the job by means of random observations. It is one of the most widely used techniques for analysing non-repetitive work. The foreman or the supervisor can use this technique and still perform almost all his other unctions. It is also based on the theory of proba ɔility, and its reliability and validity can be statistically examined.

The present study was taken up to devise a technique for the analysis on non-repetitive work using symbols and charts, analogous to those used in motion study of repetitive work (2). It was attempted to make the technique as simple as possible so that it could be applied to any type of non-repetitive job.

As will be apparent from the description of the various approaches to the analysis of non-repetitive work, every technique requires direct observation of the worker while carrying out his tasks. This observational phase of analysis and recording activities is essentially a psychological phenomenon. Hence a psychometric assessment of the quality of observation is essential. It was therefore considered necessary to find out the reliability and validity of the proposed technique. It becomes all the more important as the current literature does not give any such estimates regarding the prevalent techniques of work study with the exception of the work sampling technique (5).

To test the applicability of the technique four different types of jobs were analysed. It was arranged so that the observations were made by the ordinary supervisors or the workers themselves, who are not familiar with the principles of work study.

For the analysis of work activities by this technique, all the activities performed by the workers should be listed in consultation with the workers themselves, their supervisors and by direct observation. These activities should be classified in suitable categories such that the categories are mutually exclusive and comprehensive. These classificatory categories are to be properly defined and each allocated a symbol. A motion and time chart should also be devised to record the time of starting any activity, the classificatory symbol, short description of the activity in one or two words and the quantity of work in cases where it can be objectively determined.

In the present investigation the following four jobs were taken up for analysis : (i) Research Scholar ; (ii) Stenographer ; (iii) Office Helper or Messenger boy ; (iv) Laboratory Assistant.

Three sets of categories were devised, one each for the jobs of research scholar and stenographer and a common set for office helpers and laboratory assistants. Each catagory was separately defined and examined to see whether it was comprehensive and exclusive. Instructions were also written and arranged with the

definitions, indicating how they were to be used, and how the motion and time charts were to be completed. A common chart was devised for all the jobs.

For the collectoin of the data, charts, instruction sheets and classificatory catagories along with their symbols and definitions were distributed to the research workers and stenographer, and to supervisors in case of laboratory assistants and office helpers. The purpose of the study was explained and they were requested to keep a record of all the activities performed by the workers concerned for the full day's duties. The charts were to be maintained for a period of at least one full working week.

Results

The data obtained from these four jobs were tabulated in terms of frequency of activities and time spent on each activity for each day for each worker. Averages per day were found out by units of one or more weeks. This average time per operation was converted into a percentage of total time. Tables 1 to 3 give these percentages separately for research scholars, stenographers, and office helpers and laboratory assistants. From the tables, the performance of workers can easily be compared against one another as well as from one period of observation to another in case of the same worker.

Both intra-worker and inter-worker reliabilities were determined by computing the product moment correlation, applying the formula given in standard texts (3). For intra-worker reliability, the correlation was obtained between the percentages of time devoted by the same worker to different operations during two different periods of observation. Similarly for inter-worker reliability, the correlation was computed between the percentages of time devoted in each operation by two different persons having similar jobs studied during the same period. These reliability coefficients are give in Table 4.

To find out the validity of the proposed technique, it must be tested against some standard criterion. For this purpose, work sampling technique was chosen as it has been applied previously to non-repetitive work and its reliability and validity have been tested for work study (1). While the original data were recorded by the workers or their supervisors and were for the full working day, work sampling data were collected by the author, who took observations at times selected by random sampling. Those workers already observed by the proposed technique, were also observed by the work sampling technique. It was also noted, while collecting data by the work sampling technique, that the load of work and nature of work had changed slightly since the original observations were made, in case of office helpers, stenographer and one of the research scholars. This fact was noted to be kept in mind while judging the results of validity coefficients for different workers and different jobs. The work sampling frequencies were converted into percentages to estimate the amount of time devoted by each worker in different categories of activities. These percentages were correlated, using product-moment formula (3), with the percentages obtained from motion and time charts for the corresponding workers, to obtain the validity coefficients presented in Table 5.

Discussion

The results can be discussed in terms of the purposes of the study. As the results indicate, this technique has given high reliability coefficients for the types of jobs studied. It is highly consistent from one worker to another employed in the same job and the technique also gives consistent results in case of the same worker from one observation to another. The majority of the coefficients are significant at the 1 per cent level and all of them are significant at the 5 per cent level. (Table 4). These results suggest that this technique is reliable for analysis of non-repetitive work.

With regard to validity of the technique, the results indicate significant validity for laboratory assistants and one of the research scholars (Table 5). In the case of others, low validity was found which may have been due to many factors, for example, change in the nature and load of work during the period elapsing between original observations and work sampling, incomplete reports often made by the workers and supervisors due to pressure of work.

As the technique has shown a considerable degree of reliability and validity for several quite different jobs, it can be recommended for wider use. The classification of work activities must, of course, be carried out for each type of work. However, with little training and explanation, the regular supervisors can be entrusted with collection of the data and also, for higher level jobs, the workers themselves can be asked to maintain the records.

It can be hoped that with wider application, this technique will be found useful for all types of non-repetitive jobs, in industry as well as in the office, for example, for such jobs as those of supervisors, draftsmen, engineers and maintenance men. It can also be usefully employed for comparing the performance of different workers on the same job (Tables 1 to 3). It may therefore be used as a basis for establishing time standards for different activities in different jobs of a non-repetitive nature. Besides this, industry can adopt this technique for collecting performance records by their supervisors without imparting any special training to them. As illustrated in this study they can employ it with general explanations, and some categories of workers can be relied upon to maintain such records themselves.

The study also indicates the importance of psychometricians for such studies. As discussed earlier there is more than one technique for the analysis of non-repetitive work but none with the exception of work-sampling technique, has got a scientific basis. All however depend basically on observations by a human observer. It is the role of psychometricians to test the reliability and validity of the various techniques and other measuring tools to improve them and to demonstrate their worth before advocating their general use in business and industry.

Summary

1. A technique was developed for the analysis of non-repetitive work as a necessary preliminary for work study. Its applicability to four different types of jobs research worker, stenographer, laboratory assistant and office helper was illustrated.

2. The reliability of the technique was determined by comparing performance of one person against another in the same job and for the same person from one observation period to another. Results indicate dependable reliability in the majority of cases.

3. The validity of the technique was examined by comparing the proportion of time devoted to different activities of a job as obtained by this technique and the work-sampling technique. The results indicate considerable validity for many workers, however further investigation is required to establish this as a general feature of the technique.

4. The technique was also found useful for comparing the performance of one individual with another on the same job and could be employed for establishing time-standards for different actitivies in different jobs.

5. Psychometric methods were illustrated as appropriate and suitable to investigate and establish the quality of observation.

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TABLE 1

Work Study Data for Non-Repetitive Work : Research Scholar Allocation of Time in Percentages

(Self-Reported)

Serial number	Nature of Work	Symbol	Successive Periods of Observation											
			Period I (4 weeks)—Persons				Period II (3 weeks)—Persons				Period III (2 weeks)—Persons			
			1	2	3	4	1	2	3	4	1	2	3	4
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1	Job Oriented Work ...	*	81·3	82·0	79·6	87·8	92·5	88·6	80·8	89·4	84·3	84·1	84·3	86·3
2	Miscellaneous Task ...	M	18·7	18·0	20·4	12·2	7·5	11·4	19·2	10·6	15·7	15·9	15·7	13·7
3	Reading ...	L	70·3	70·3	78·3	50·1	57·4	45·5	66·7	37·	47·9	68·0	46·6	20·4
4	Discussion ...	D	1·8	·7	·3	·9	1·9	4·3	1·8	3·9	7·8	1·3	·5	7·3
5	Machine Calculation	C	1·4	·5	...	...	5·9	14·3	1·3	...	...	·8	...	...
6	Practical Exercises ...	E	4·6	1·4	...	...	18·2	24·1	11·0	...	5·6	10·6	37·2	...
7	Writing Reports ...	W	...	...	...	21·2	...	...	...	15.2	...	...	...	...
8	Field Work ...	F	...	1·1	·5	...	3·2	...	...	...	...	...	...	...
9	Testing Work ...	T	3·2	8·0	·5	15·6	5·9	·4	...	33·3	23·0	3·4	...	58·6

* Percentage of time devoted to all activities other than miscelaneous.

TABLE 2

Work Study Data for Non-Repetitive Work : Stenographer, Allocation of Time in Precentages

(*Self-Reported*)

Serial number	Nature of Work	Symbol	Successive Periods of Observation			
			I	II	III	IV
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	Job Oriented Work	*	92.4	87.2	93.3	91.9
2	Miscellaneous Task	M	7.6	12.8	6.7	8.1
3	Dictation and Transcription ...	D	35.5	29.8	18.9	19.4
4	Attending Phone Calls ...	P	9.4	15.9	12.7	7.5
5	Typing for Rotaprint ...	T R	17.9	21.3	4.4	48.0
6	Typing for Other Papers ...	T P	5.7	7.2	40.0	...
7	Correspondence—Despatch ...	C D	8.7	2.4	14.4	13.1
8	Correspondence—Independent.	C I	6.6	5.8	2.4	...
9	Store Management ...	S & S R D	1.2	3.2	.5	3.9
10	General Supervision ...	G G R M	5.5	...	...	...
11	Filing	F & F D D	1.9	1.6		

*Percentage of time devoted to all activities other than miscellaneous.

TABLE 3

Work Study Data for Non-Repetitive Work : Laboratory Assistants and Office Helpers, Allocation of Time in Percentages

(Data Reported by the Supervisors)

Serial number.	Nature of Work	Symbol	Successive Periods of Observation								
			Period I(1 week)—Persons						Period II (1 week)—Persons		
			1	2	3	4	5	6	4	5	6
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1	Job Oriented Work	*	85.2	70.0	67.3	86.7	74.9	88.8	92.9	84.5	87.1
2	Miscellaneous Task	M	8.2	24.2	14.0	13.3	25.1	11.2	7.1	15.5	12.9
3	Office Maintenance	O	...	1.1	...	19.9	...	.6	18.6	...	...
4	Carrying	C	2.2	...	...	58.0	...	...	47.9	8.5	...
5	Assisting in Clerical Work	A	18.4	...	2.9	...	57.8	54.7	...	73.2	65.7
6	Work on Duplicating Machines	D	...	...	...	...	...	22.9	...	...	...
7	Semi-Manual	S	...	4.0	...	4.8	17.1	1.1	26.4	...	...
8	Technical	T	64.6	63.6	62.2	2.4	...	7.1	...	...	18.6
9	Waiting	W	...	1.3	2.2	1.6	...	2.4	...	2.8	2.8
10	Time Unaccounted for	U	6.6	5.8	18.7	...	...	...	...	...	...

* Percentage of time devoted to all activities other than miscellaneous and unaccounted for time.

TABLE 4

Intra-Worker and Inter-Worker Reliability of the Work Study Technique for Non-repetitive Work

Serial number	Jobs	Intra-Worker Reliability		Inter-Worker Reliability	
		Worker 1	Worker 2	Pair of Workers 1	Pair of Workers 2
(1)	(2)	(3)	(4)	(5)	(6)
1	Research Scholar	.99**	.89*	.99**	.89**
2	Laboratory Assistant	...	...	.91**	.88**
3	Office Helper	.88**	.85*	...	...
4	Stenographer	.98**	...	...	...
	(For two different periods of observation)	.89**	...	...	...

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

TABLE 5

Validity Coefficients for the Work Study Technique for Non-repetitive Work : Correlations with Work Sampling Data

Serial number.	Jobs	Workers		
		1	2	3
(1)	(2)	(3)	(4)	(5)
1	Research Scholar	.94**	.28†	...
2	Laboratory Assistant	.93*	.89**	.62†
3	Office Helper	.46†	.94	.40†
4	Stenographer	.61†	...	...

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

† A period of 5 weeks had elapsed between the collection of data by work sampling and by the proposed technique during which nature of work and load of work had changed considerably.

Note :—

1. The tables present the original data in percentage form. For Table 1, four research scholars were studied ; for Table 2, one stenographer was studied ; for Table 3, six laboratory assisatnts and office helpers were studied.

2. The reliability coefficients were product-moment correlations computed between pairs of columns for the appropriate tables. Thus, intra-worker reliability for the research scholars was computed between columns (6) and column (10) for Table 1 for worker 1 and between columns (9) and (13) of the same table for worker 2. Pairs of columns from different tables were similarly examined to obtain intra-worker reliabilities. For inter-worker reliability, the correlations were computed between columns for two persons carrying out similar types of work during the same period of observation. For example, the intra-worker reliability for research scholars was computed between columns (4) and (5) of Table 1 to obtain one coefficient and between columns (5) and (7) of Table 1 to obtain the other coefficient reported in Table 4. Similarly, pairs of columns were chosen representing different persons carrying out the same type of work for other inter-worker reliabilities.