International Journal of Creative and Open Research in Engineering and Management
ISSN: **3108-1754 (Online)**
Volume 02 Issue 07 Jul-2026 | Impact Factor: 3.5

Productivity Enhancement Through Time and Motion Study Techniques

GAURAV KUMAR , ROUNAK SINGH , RAGHUVEER SINGH , JAYSHREE KUMAR
BIDHAN CHANDRA MONDAL , MD SAMIR ANSARI , SUMIT GANGULY

DEPARTMENT OF MECHANICAL ENGINEERING
K.K POLYTECHNIC, DHANBAD, JHARKHAND, INDIA

How to Cite this Article:

KUMAR, G., SINGH, R., SINGH, R., KUMAR, J., MONDAL, B. C., ANSARI, M. S. & GANGULY, S. (2026). Productivity Enhancement Through Time and Motion Study Techniques. International Journal of Creative and Open Research in Engineering and Management, <i>02</i>(7), 1-9. https://doi.org/10.55041/ijcope.v2i7.258

https://doi.org/10.55041/ijcope.v2i7.258

Abstract — Productivity remains the central measure of how efficiently an organisation converts labour, material, and machine time into useful output, and few engineering tools have influenced this measure as deeply as time and motion study. This paper presents a concise, tutorial-style review of time and motion study techniques written for diploma and undergraduate engineering readers who are meeting the subject for the first time. It traces the origin of the discipline through the independent but complementary contributions of Frederick Taylor's time study and the Gilbreths' motion study, and explains the fundamental principles of each in plain language. The paper describes a practical, step-by-step methodology for conducting a work study, covering direct time study using a stopwatch, performance rating, and the calculation of standard time, alongside the motion-study tools of process charts, therbligs, and the principles of motion economy. It then reviews how these techniques are applied across both manufacturing and service industries, drawing on documented case examples from garment production, machining, and hospital nursing workflow, and discusses the benefits, limitations, and practical challenges that arise when work study is introduced on the shop floor. The paper closes with a review of productivity improvement techniques that build on work-study data, a look at how digital sensing and automation are reshaping the field, and conclusions for practitioners. The paper is intended as a self-contained academic reference connecting the classical foundations of work study with its continuing relevance in modern productivity engineering.

Key Words: Time study, motion study, work study, productivity, standard time, therbligs, motion economy, work measurement, method study, industrial engineering.

1. INTRODUCTION

Productivity is generally defined as the ratio of useful output obtained to the resources consumed in producing it, and improving this ratio is one of the oldest and most persistent goals of industrial engineering. Long before computers and automated sensors could measure a workstation in real time, engineers relied on careful direct observation of how work was actually being performed, and this observation-based approach came to be known as time and motion study. The technique remains relevant today precisely because it addresses a problem that has never gone away: no matter how advanced the machinery on a shop floor is, the overall pace of production is still governed by how efficiently people and machines interact at each individual workstation.

Time and motion study is, in practice, two closely related but historically distinct techniques that are almost always discussed together. Time study is concerned with measuring how long a task takes when performed by a trained worker at a defined pace, so that a fair standard time can be established for planning, costing, and incentive purposes. Motion study is concerned with analysing the body movements used to perform a task, so that unnecessary, awkward, or fatiguing movements can be identified and eliminated, leaving a simpler and less tiring method of working. Used together under the broader heading of work study, the two techniques answer two different but complementary questions: motion study asks "is this the best way to do the job?" while time study asks "how long should the best way take?"

This paper is written as an introductory academic reference for diploma and undergraduate engineering students encountering work study for the first time. Rather than assuming prior exposure to industrial engineering terminology, the paper builds the subject from its historical origins, develops the fundamental principles of time study and motion study separately, presents a practical methodology that a student could follow in a college laboratory or a small workshop, and then broadens the discussion to real applications, benefits, limitations, and the productivity improvement techniques that depend on work-study data. The paper closes with two originally written case examples illustrating how the techniques play out in a manufacturing and a service setting, followed by a discussion of future scope and overall conclusions.

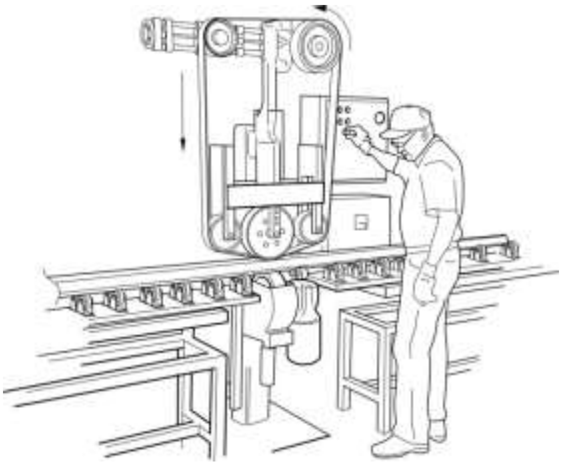

Fig 1. Industrial Engineer Performing a Stopwatch Time Study

2. OBJECTIVES

The specific objectives of this paper are as follows: first, to explain the historical development and underlying principles of time study and motion study in language accessible to students without prior exposure to industrial engineering; second, to describe a practical, replicable methodology for conducting a stopwatch time study and a motion study using standard process-charting tools; third, to review how these techniques are applied in both manufacturing and service industries, supported by illustrative case examples; fourth, to critically examine the benefits that organisations gain from work study alongside the practical limitations and challenges that commonly arise during implementation; and fifth, to connect the classical foundations of work study with the productivity improvement techniques and digital tools that are extending its relevance in modern industry.

3. LITERATURE REVIEW

The foundations of time study are usually traced to Frederick Winslow Taylor, an American mechanical engineer who, in the closing years of the nineteenth century, began timing individual elements of factory work with a stopwatch in an effort to determine a fair day's work for a fair day's pay [1]. Taylor's central argument, published in his influential work on scientific management, was that management should study work scientifically rather than rely on tradition or the informal judgement of experienced workers, and that a properly measured standard time could form the basis for planning, wage incentives, and performance evaluation.

Working at roughly the same period but from a different angle, Frank Gilbreth and his wife Lillian Gilbreth developed motion study as a distinct but complementary discipline. Where Taylor's concern was primarily how long a task took, the Gilbreths were concerned with how the task was physically performed, and they used motion-picture cameras to record and analyse the body movements of skilled workers, most famously bricklayers, in order to identify and eliminate wasteful motion [2]. Their later work introduced a standard vocabulary of basic hand motions, later named "therbligs" (an approximate reversal of the name Gilbreth), which allowed any manual task to be broken down into a common set of elemental motions for analysis [2][3]. Lillian Gilbreth, notably one of the first women to earn a doctorate in industrial psychology, extended this work to incorporate the psychological and physiological aspects of fatigue, arguing that a method that reduced unnecessary motion also reduced worker fatigue and, over a working day, sustained higher output [3].

Over the following decades, time study and motion study were increasingly presented as a single combined discipline, generally referred to as work study or, in North American usage, methods engineering. Ralph Barnes's widely used textbook on motion and time study systematised much of this material into the methodology still taught today, including standardised process-chart symbols and formal procedures for performance rating [4]. The International Labour Office's manual on work study, first published in the mid-twentieth century and repeatedly revised since, became a standard reference used across developing and industrialised economies alike, particularly in vocational and technical education [5]. More recent textbooks, such as the work of Niebel and Freivalds, have kept the discipline current by incorporating ergonomic principles, computer-aided time study software, and predetermined motion-time systems into what remains, at its core, the same basic Taylor–Gilbreth framework [6].

Contemporary research continues to apply these classical techniques to present-day production and service problems. Guha and Verma documented a combined time and motion study of a tractor-loader-backhoe production line, showing how the identification of non-value-adding activities and awkward postures could be used together to redesign a workstation [7]. Rajiwate et al. applied similar techniques to reduce cycle time and improve layout in a small manufacturing unit, reporting a measurable productivity gain after implementing the recommended method changes [8]. Khatun studied the effect of time and motion study on productivity in the garment sector, a labour-intensive industry where small improvements in hand-motion efficiency accumulate into a large effect across thousands of repeated operations per shift [10]. The techniques have also proved useful well outside conventional manufacturing: Hendrich et al. conducted a large, thirty-six-hospital time and motion study of medical-surgical nurses to identify how much of a nursing shift was spent on direct patient care versus documentation and other indirect activities, demonstrating that the same observation-based methodology developed for factory work applies equally well to complex service environments [12]. Taken together, this body of literature shows a discipline that, while originating over a century ago, continues to generate practical, measurable productivity gains whenever it is applied carefully.

Figure 2. Evolution of Time Study and Motion Study from Taylor to the modern work-study approach.

4. FUNDAMENTALS OF TIME STUDY

Time study is a work-measurement technique used to determine the time required by a qualified, trained worker to carry out a specified task at a defined level of performance, following a specified method. The output of a time study is a figure known as the standard time, which becomes the basis for production planning, labour costing, line balancing, and, in many organisations, incentive wage schemes.

Before any timing takes place, the task must first be broken down into a series of small, clearly identifiable elements — short segments of work with a definite beginning and end point that can be recognised consistently every time the cycle repeats. Breaking a task into elements serves two purposes: it makes the timing more accurate, since short, well-defined elements are easier for an observer to time consistently than one long, continuous cycle, and it allows the analyst to apply a separate performance rating to each element, since some parts of a job may be performed faster or slower relative to a normal pace than others.

Once elements are defined, the analyst times a number of complete cycles of the job using a stopwatch (or, in modern practice, a digital timer or dedicated time-study software), recording the observed time for each element on every cycle. Because no worker performs a task at exactly the same pace on every cycle, and because the worker being observed may not be working at what would be considered a normal or standard pace, the analyst applies a performance rating — a percentage judgement, typically expressed relative to 100 percent representing "normal" pace, of how the observed worker's speed and effectiveness compares with that normal pace. Multiplying the observed time for each element by its performance rating gives the normal time for that element.

Normal time alone is not yet a usable standard, because it makes no allowance for the unavoidable interruptions and physical needs of a real working day: personal needs such as short rest breaks, fatigue arising from physical or mental exertion, and unavoidable delays such as waiting for material or a minor machine adjustment. A percentage allowance, typically derived from company policy, published tables, or negotiated agreement, is therefore added to the normal time to produce the standard time, which represents a fair and achievable time for the task under normal working conditions. In equation form, Standard Time equals Normal Time plus Allowances, where Normal Time equals Observed Time multiplied by the Performance Rating (expressed as a fraction). This single figure, once established, remains the reference point for almost every subsequent productivity comparison discussed later in this paper.

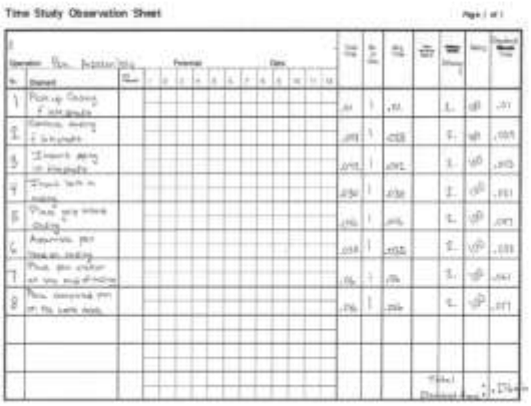

Figure 3. Example of a stopwatch time-study recording sheet used for cycle-time measurement.

5. FUNDAMENTALS OF MOTION STUDY

Motion study is concerned not with how long a task takes, but with how the task is physically performed, with the aim of designing the simplest, least fatiguing, and most efficient method of doing the work before that method is ever timed. The underlying belief, inherited directly from the Gilbreths, is that a poorly designed method can never be made efficient simply by working faster; the method itself must first be improved.

The most basic tool of motion study is the process chart, which records every step of a task — operation, transportation, inspection, delay, and storage — using a small set of standard symbols, allowing the analyst to see at a glance how much of a job consists of value-adding work (an operation that changes the product or its position for the better) as opposed to non-value-adding activity such as unnecessary movement, waiting, or temporary storage. A related tool, the two-handed process chart, records the movements of the left and right hands separately and side by side, which is particularly useful for identifying idle time in one hand while the other hand is working, a very common source of hidden inefficiency in manual assembly tasks.

International Journal of Creative and Open Research in Engineering and Management
ISSN: **3108-1754 (Online)**
Volume 02 Issue 07 Jul-2026 | Impact Factor: 3.5

For a finer level of detail, the Gilbreths' system of therbligs breaks any manual motion down into a standard set of elemental movements, such as reach, grasp, move, position, and release, each represented by its own symbol. By recording a task therblig by therblig, an analyst can identify which elemental motions are truly necessary and which can be eliminated, combined, simplified, or rearranged into a shorter sequence.

Motion study is guided in practice by a set of principles known as the principles of motion economy, first compiled systematically by Barnes and still taught in essentially the same form today. These principles fall into three broad groups. Principles concerning the use of the human body recommend that both hands should begin and complete their motions at the same time, that motions should be smooth and curved rather than sharp and zigzagged, and that momentum should be used to assist the worker wherever possible rather than being fought against with muscular effort. Principles concerning the arrangement of the workplace recommend that tools and materials should have fixed, easily reached locations, and that gravity-fed containers or bins should be used to deliver material to the point of use wherever practical. Principles concerning the design of tools and equipment recommend combining two or more tools into one wherever possible and pre-positioning tools so that they are ready for immediate use rather than requiring a search or reorientation. Applied together, these principles are the practical bridge between motion study analysis and an actually improved workstation design.

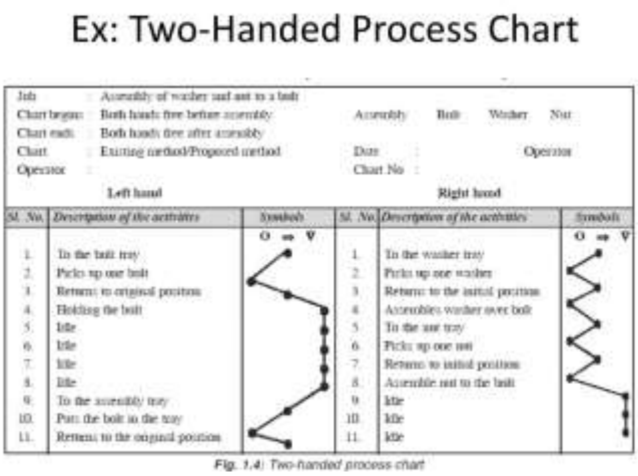

Figure 4. Two-handed process chart illustrating coordinated left- and right-hand movements during manual assembly.

6. METHODOLOGY

Although time study and motion study are conceptually distinct, they are almost always carried out together as a single work-study exercise, following a logical sequence of steps that begins with selecting the job to be studied and ends with implementing and maintaining the improved method. Table 1 outlines this sequence as it would typically be followed in an industrial or academic setting.

Table 1: Typical Sequence of Steps in a Combined Time and Motion Study

Step	Activity	Purpose
1	Select the job or process to be studied	Prioritise high-volume, high-cost, or problem-prone operations
2	Record the existing method (process chart, two-handed chart)	Establish an accurate picture of current practice
3	Examine the recorded method critically	Question the purpose, place, sequence, person, and means of each step
4	Develop and select an improved method	Apply principles of motion economy to remove unnecessary motion
5	Break the improved method into	Prepare the job for accurate

	measurable elements	stopwatch timing
6	Time a representative number of cycles	Record observed time for each element
7	Apply performance rating and allowances	Convert observed time into a fair standard time
8	Define and install the new standard method	Train workers and update work instructions
9	Maintain the standard through periodic review	Ensure the method and standard remain valid over time

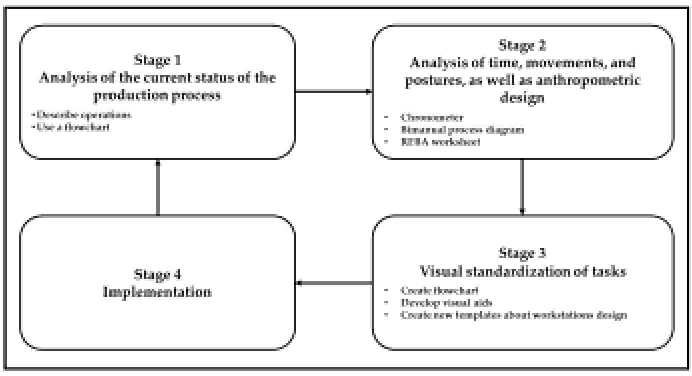

Figure 5. Typical work-study cycle from job selection to continuous improvement.

The recording step (Step 2 in Table 1) is normally carried out directly at the workplace rather than from memory or a written description, since even an experienced worker's account of their own method often differs in small but important ways from what they actually do. The critical examination step (Step 3) is traditionally guided by a structured questioning technique that asks, for every element of the recorded method: what is its purpose, where is it carried out, in what sequence, by whom, and by what means — and, for each answer, whether an alternative would serve better. This structured questioning is what turns motion study from a passive recording exercise into an active source of improvement ideas.

For the timing steps (Steps 5–7), a decision must be made about the number of cycles to observe. Too few cycles produce a standard time that is unreliable because it does not average out the natural cycle-to-cycle variation in any manual task; too many cycles waste analyst time without meaningfully improving accuracy. A commonly taught approach is to time a small preliminary sample, calculate the variability of the observed times, and use a standard statistical formula to determine the number of additional cycles needed to achieve a desired confidence level and accuracy — typically 90 to 95 percent confidence within 5 percent of the true mean value for classroom and small-industry purposes. Performance rating (Step 7), by contrast, remains a skill that develops mainly through training and practice; several rating systems exist (including the Westinghouse system, which rates skill, effort, conditions, and consistency separately), but all share the same underlying purpose of adjusting an individual observed worker's pace to a common "normal pace" reference before allowances are added.

Finally, Steps 8 and 9 are frequently the weakest link in student and small-industry projects, since it is common to invest considerable effort in recording, examining, and timing a job, only to see the improved method quietly abandoned once workers revert to old habits or once product changes make the original study outdated. A work-study exercise is only complete once the new method has been properly documented, workers have been retrained in it, and a mechanism exists for reviewing the standard whenever the process, material, or equipment changes.

7. APPLICATIONS IN MANUFACTURING AND SERVICE INDUSTRIES

Time and motion study originated in manufacturing and remains most widely used there, but the underlying methodology — observe, measure, question, and improve — transfers readily to any setting where a task is repeated often enough for careful measurement to be worthwhile. Table 2 summarises representative applications across several industry sectors.

Table 2: Representative Applications of Time and Motion Study Across Industry Sectors

Sector	Typical Application	Primary Objective
Automobile and component manufacturing	Assembly-line balancing; workstation layout redesign	Reduce cycle time; balance workload across stations
Garment and textile industry	Sewing operation standard-time setting	Set piece-rate wages; identify motion-economy gains
Machining and metalworking	Setup time reduction; tool and fixture positioning	Reduce non-cutting time; increase machine utilisation
Healthcare (hospitals, clinics)	Nursing workflow and task-time observation	Identify non-value-adding activity; improve patient care time
Retail and warehousing	Order-picking route and motion analysis	Reduce travel distance and picking time
Food service and hospitality	Kitchen workstation and service-counter layout study	Reduce customer waiting time; balance staff workload

In discrete-parts manufacturing, work study is most commonly used for assembly-line balancing, where the standard time for each operation is used to divide the total work content of a product as evenly as possible across the available workstations, minimising idle time at any one station and thereby maximising the overall output rate of the line. In machining operations, motion study is applied chiefly to setup and tool-changing activities, since these are typically non-value-adding from the customer's point of view yet can occupy a disproportionate share of available machine time if the tool layout and changeover sequence are not carefully designed.

In service industries, the same techniques are applied to tasks that are repeated by staff rather than by machines. In healthcare, as discussed in Section 3, time and motion study has been used extensively to document how nursing staff divide their time between direct patient care, documentation, and other indirect activities, with the explicit aim of freeing up more time for direct care without increasing staffing levels [12]. In retail and warehousing, motion and layout analysis is applied to order-picking routes, where even small reductions in the average walking distance per order accumulate into a substantial productivity gain when multiplied across thousands of orders picked per day. In each of these service contexts, the core work-study logic remains unchanged from its manufacturing origin: record the actual method, question it critically, and re-measure the improved method to confirm the gain.

8. BENEFITS OF TIME AND MOTION STUDY

When properly conducted, time and motion study delivers benefits at several levels of an organisation. At the level of the individual workstation, it typically results in a simpler, less physically tiring method of work, since the systematic removal of unnecessary motion under the principles of motion economy directly reduces the physical effort a worker must expend to complete a given task. At the level of the production line or department, the standard times generated by time study make it possible to plan production schedules accurately, calculate realistic labour and machine requirements, and balance workload evenly across workstations, avoiding the situation where some workers are idle while others are overloaded.

At the level of the whole organisation, work-study data provides an objective basis for costing, for setting fair wage-incentive schemes, and for comparing the efficiency of alternative methods, machines, or layouts before committing to a capital investment. Because the standard time represents a fair and achievable pace rather than either an unrealistically fast or a padded, unrealistically slow figure, it also tends to improve labour relations when it is developed transparently and with worker participation, since workers can see that the standard reflects an actual, demonstrated method rather than an arbitrary management estimate. Finally, because motion study reduces unnecessary physical strain, it also has a documented secondary benefit in reducing worker fatigue and, over time, the risk of repetitive-strain and musculoskeletal injury associated with poorly designed manual tasks.

9. LIMITATIONS AND CHALLENGES

Despite its long history and demonstrated benefits, time and motion study has real limitations that a practitioner must manage carefully. The most frequently raised concern is the subjectivity of performance rating: because rating depends on the trained judgement of the analyst rather than an objective instrument, two different analysts observing the same worker may arrive at somewhat different ratings, and an inexperienced analyst can introduce significant error into the resulting standard time. This subjectivity has historically also been a source of friction between workers and management, since a standard perceived as too tight (set too fast) can create resentment, while a standard perceived as too loose (set too slow) undermines the credibility of the entire incentive system.

A second limitation is the well-documented "observer effect," in which workers who know they are being timed may consciously or unconsciously change their normal pace or method, whether to appear more efficient or, in some cases, to protect a favourable existing standard, making the observed data less representative of true normal working conditions than intended. Time study is also inherently better suited to short-cycle, repetitive manual work than to long-cycle, highly variable, or largely cognitive tasks, since the underlying assumption of a repeatable, element-based cycle breaks down when a task differs substantially from one occurrence to the next, as is common in skilled maintenance work, creative or knowledge-based tasks, and many managerial roles.

Finally, a work-study programme requires an ongoing investment of trained analyst time, and studies that are conducted once and then never revisited quickly become inaccurate as products, materials, tools, and worker populations change, effectively wasting the original investment. Successful implementation therefore depends as much on organisational commitment to maintaining and periodically re-validating standards as it does on the technical correctness of the original study.

10. PRODUCTIVITY IMPROVEMENT TECHNIQUES

Time and motion study rarely operates in isolation; in most modern productivity programmes it functions as the measurement foundation that feeds a broader set of improvement techniques. Table 3 summarises several widely used techniques and shows how each depends on, or extends, work-study data.

Table 3: Productivity Improvement Techniques Related to Time and Motion Study

Technique	Focus Area	Relationship to Time and Motion Study
Work sampling	Estimating proportion of time spent on activity categories	An alternative, statistically based measurement method for long-cycle or irregular work
Line balancing	Distributing work content evenly across stations	Uses standard times directly to calculate station workload
Value stream mapping	Visualising material and information flow across a process	Uses cycle and standard times to identify non-value-adding steps
Predetermined motion-time systems (e.g. MTM, MOST)	Estimating standard time without direct stopwatch observation	Builds on therblig-level motion analysis pioneered by the Gilbreths
Lean manufacturing / waste elimination	Removing the seven classical forms of waste	Uses process-chart and motion-economy findings to target waste

Ergonomic workstation redesign	Reducing physical strain and injury risk	Applies motion-economy principles alongside anthropometric data

Work sampling, unlike continuous stopwatch time study, estimates how a worker's or machine's time is divided among defined activity categories by taking a large number of instantaneous random observations rather than timing every cycle continuously; it is particularly useful for long-cycle or irregular work, such as maintenance activity or hospital nursing tasks, where continuous timing would be impractical. Predetermined motion-time systems, such as Methods-Time Measurement (MTM) and Maynard Operation Sequence Technique (MOST), extend the Gilbreths' therblig concept into standardised tables of time values for elemental motions, allowing an analyst to estimate a standard time for a proposed method before it is ever physically performed, which is especially valuable during the design of a new product or workstation. Lean manufacturing techniques, including value stream mapping and the systematic elimination of the seven classical forms of waste (overproduction, waiting, transport, over-processing, inventory, motion, and defects), draw directly on work-study data to identify which process steps genuinely add value for the customer and which do not. In each case, the accuracy of the higher-level improvement technique depends on the quality of the underlying time and motion data, underscoring why the classical work-study skillset remains foundational to modern industrial engineering practice rather than being replaced by it.

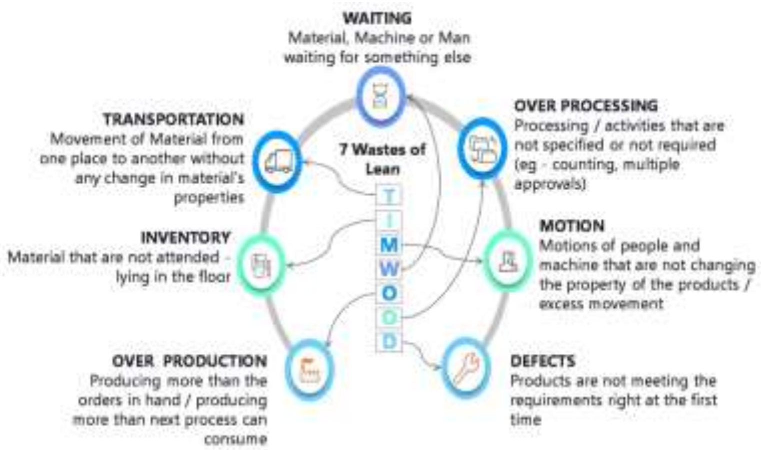

Figure 6. Lean manufacturing wastes addressed through time and motion study.

11. CASE EXAMPLES

The following two case examples are original illustrative scenarios, written for this paper to demonstrate how the methodology described in Section 6 might be applied; they are not drawn from any specific published case and should be read as representative teaching examples rather than as reports of an actual industrial study.

11.1 Manufacturing Example: Small Component Assembly Station

Consider a small assembly station where an operator fits a bracket, two screws, and a spring clip onto a base component. A motion study of the existing method, recorded using a two-handed process chart, might reveal that the operator's left hand remains idle while the right hand alone locates each screw from a mixed parts bin, positions it, and drives it home with a powered screwdriver, before the left hand is used only to hold the base steady. Applying the principles of motion economy, an improved method could relocate the parts into three separate, gravity-fed bins positioned within easy reach of each hand, and re-sequence the task so that the left hand simultaneously locates the next screw while the right hand drives the current one. A subsequent time study of both methods, timed over a representative number of cycles with an appropriate performance rating and allowance applied, would be expected to show a meaningfully lower standard time for the improved method, primarily because idle hand time has been converted into productive, overlapping motion rather than because the operator is asked to move any faster.

11.2 Service Example: Hospital Outpatient Registration Desk

Consider an outpatient registration desk where a receptionist verifies patient identity, checks insurance details, and issues a token number before each consultation. A process-chart recording of the existing method might show that the receptionist frequently switches between a paper appointment register and a computer terminal positioned at an awkward angle, requiring repeated turning and reaching motions between the two. Reorganising the desk so that both the register and the terminal screen are within a single, comfortable field of view and reach — consistent with the principles of motion economy discussed in Section 5 — together with a revised sequence that completes all paper-based checks before switching to the terminal, would be expected to reduce both the physical strain on the receptionist and the average time to process each patient. A time study comparing patients processed per hour before and after the change provides the organisation with objective evidence of the improvement, in the same spirit as the nursing workflow studies discussed earlier in this paper [12].

12. FUTURE SCOPE

The core logic of time and motion study — record the actual method, question it critically, and measure the improved method objectively — is unlikely to become obsolete, but the tools used to carry it out continue to evolve. Wearable sensors and computer-vision systems are increasingly able to record worker motion automatically and continuously, reducing dependence on a human analyst standing beside the workstation with a stopwatch and potentially reducing the observer effect discussed in Section 9, since workers may adapt to an unobtrusive camera or sensor differently than to a visibly present analyst. Data collected in this way can also be analysed using statistical and machine-learning methods to detect patterns of inefficiency or ergonomic risk that would be difficult for a human observer to notice across a full shift of continuous work.

The growing integration of these digital tools with traditional work-study thinking, sometimes discussed under the broader heading of Industry 4.0, suggests that future practitioners will need to combine classical work-study skills — element definition, performance rating judgement, and motion-economy principles — with basic competence in data analysis and sensor-based measurement systems. In service sectors such as healthcare and retail, where continuous direct observation is often impractical at scale, work sampling and automated location or activity tracking are likely to see continued growth as more practical alternatives to full stopwatch time study. Regardless of the measurement technology used, the underlying engineering judgement developed through classical time and motion study is likely to remain the foundation on which these newer tools are interpreted and applied.

Figure 8. Integration of digital sensing and Industry 4.0 technologies with modern work-study systems.

13. CONCLUSION

Time and motion study, though more than a century old, remains a foundational technique for productivity engineering because it addresses a question that automation alone cannot answer: whether a given task, however it is performed, is being carried out in the simplest and most efficient way available. This paper has traced the technique from its origins in Taylor's time study and the Gilbreths' motion study through a practical, step-by-step methodology, and has shown, through documented literature and original case examples, how the same underlying logic applies equally well in a manufacturing workstation and a hospital registration desk. While performance-rating subjectivity, the observer effect, and the ongoing effort required to maintain standards remain real limitations, these are limitations of careful implementation rather than of the underlying methodology, and they have not prevented time and motion study from remaining a standard tool taught in industrial and mechanical engineering programmes worldwide. As sensor-based and data-driven measurement tools continue to mature, they are best understood not as replacements for time and motion study but as new instruments through which its century-old core logic — observe, question, measure, and improve — continues to be applied.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the Department of Mechanical Engineering, K.K POLYTECHNIC, GOVINDPUR DHANBAD, for providing the academic environment and resources that supported the preparation of this review paper. The authors also thankful their faculty mentors for their guidance and constructive feedback during the drafting of this manuscript. The authors declare no conflict of interest related to this work.

REFERENCES

[1] Taylor, F.W. (1911). The Principles of Scientific Management. Harper & Brothers, New York.

[2] Gilbreth, F.B., and Gilbreth, L.M. (1917). Applied Motion Study: A Collection of Papers on the Efficient Method to Industrial Preparedness. Sturgis & Walton, New York.

[3] Gilbreth, L.M. (1914). The Psychology of Management: The Function of the Mind in Determining, Teaching and Installing Methods of Least Waste. Sturgis & Walton, New York.

[4] Barnes, R.M. (1980). Motion and Time Study: Design and Measurement of Work, 7th ed. John Wiley & Sons, New York.

[5] International Labour Office (ILO). (1992). Introduction to Work Study, 4th ed. International Labour Organization, Geneva.

[6] Mundel, M.E., and Danner, D.L. (1994). Motion and Time Study: Improving Productivity, 7th ed. Prentice-Hall, New Jersey.

[7] Niebel, B.W., and Freivalds, A. (2013). Methods, Standards, and Work Design, 13th ed. McGraw-Hill, New York.

[8] Guha, S., and Verma, D.S. (2020). Time and motion study in a manufacturing industry. Journal of Emerging Technologies and Innovative Research, 7(8), 486–491.

[9] Rajiwate, A., Mirza, H., Kazi, S., and Momin, M.M. (2020). Productivity improvement by time study and motion study. International Research Journal of Engineering and Technology, 7(3), 5308–5312.

[10] Bon, A.T., and Daim, D. (2010). Time motion study in determination of time standard in manpower process. Proceedings of the International Conference on Industrial Engineering and Operations Management.

[11] Khatun, M. (2014). Effect of time and motion study on productivity in garment sector. International Journal of Scientific & Engineering Research, 5(11), 400–405.

[12] Hendrich, A., Chow, M.P., Skierczynski, B.A., and Lu, Z. (2008). A 36-hospital time and motion study: How do medical-surgical nurses spend their time? The Permanente Journal, 12(3), 25–34.

[13] Mahatme, N.N., and Dahake, S.V. (2016). Productivity improvement and cycle time reduction in CNC machining — A case study. International Journal of Research in Advent Technology, 4(4), 34–37.

[14] Meidan, Y., Lerner, B., Rabinowitz, G., and Hassoun, M. (2011). Cycle-time key factor identification and prediction in semiconductor manufacturing using machine learning and data mining. IEEE Transactions on Semiconductor Manufacturing, 24(2), 237–248.