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Teaching Methods-Time Measurement (MTM) for Workplace Design in Learning Factories

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Abstract

Methods-Time Measurement (MTM) has its roots in time studies as a predetermined motion time system. It can however also be used in the field of workplace design and improvement. High amount of work effort for the creation of MTM-analyses and time-consuming trainings in MTM often lead to a decline in the use of MTM.
A potential solution for the human resources management of companies could be practice-oriented trainings with MTM as a method for workplace design. A lot of job profiles (e.g. process engineer) in manufacturing do not need a complete MTM training, as they do not require the full time-study aspect of MTM. This article represents an approach for MTM workplace design training in a learning factory.

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Keywords: process optimisation; learning factory; assembly; workplace design

1. Introduction

Companies of the production sector are exposed to drivers like globalisation, which lead to a high amount of challenges, such as customisation of products as well as a reduction of the time-to-market [1]. The latter is determined by the product development within the product creation process [2]. Besides the product development, the process planning, which is to plan and design production systems, has a great influence on the product development. The

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decisions of this planning phase determine the whole production time of a product. This is proved by empirical studies, which show, that the results of the process planning have the second-largest influence on the product costs, just after the product development [3].

The production or working system, which is designed by the industrial engineer, also influences the product's quality and delivery time. An established method to plan and design production systems is Methods-Time Measurement (MTM) [4]. Having its roots in time management, MTM is also enormously helpful to rate work contents and to optimise production systems both prospective (before start of production) and during a running production. However, in industry MTM is not applied comprehensively as the intensive training and the high effort to generate time studies are perceived as obstacles. Yet, for the use of MTM in the field of process planning, a complete education in MTM is not necessary, as the determination of process times, which is mostly done in the division of time management, is not relevant. However, the aspects of optimisation play an important role within the process planning.

A key challenge, facing higher education institutions, is to equip industrial or production engineering students with the skills necessary to secure professional employment in a fast changing and competitive manufacturing environment. This requires such institutions to continuously search for new ways of building competencies and skills. An important aspect with regards to skills development is the method used for the transfer of knowledge. In recent years, more and more research has emphasised the benefits of experiential or action based learning, i.e. learning by doing [5, 6, 7].

Learning factories provide a promising approach to improve production related training through "learning by doing" (or action based learning) by providing a realistic "production" environment as a learning environment - this means processes and technologies inside the learning factory are realistic representations of real industrial sites. Learning factories expose learners to a real-life environment, and allow learners to apply knowledge in a realistic setting. It also provides learners the opportunity to experiment, test and discover, therefore learning by doing and trying. This enhances the learning experience, leads to better knowledge retention, and thereby contributes to better skills development.

In order to make practical trainings in MTM possible, this article presents an approach for MTM workplace design training in a learning factory. First, the theoretical background of MTM and of action-orientated knowledge transfer in learning factories is presented, followed by the approach, which was developed in the learning factory of the Stellenbosch University in South Africa.

2. MTM for workplace design

MTM is a system of predetermined times and is used for the design of working processes. Therefore, manual tasks are analysed, described, structured and planned by means of defined process modules. These are systematically structured and arranged, in order to visualise influence factors and to design working systems already in the planning phase. For this purpose, the MTM basic system MTM-1 dissects motion sequences in basic movements (Reach, Grasp, Move, Position, and Release). To each basic movement a time value is linked, which depends on defined influence factors (e.g. distances). MTM can be used for several purposes [4]. The main field of application is the time management, for which time values for manual processes are recorded and used for cost calculations, production control or enumeration.

In addition, MTM can be used throughout the entire product creation process (figure 1). Especially for process planners MTM is a useful tool. By a coordinated development of products and correlating processes, high costs for changes in late phases of the product creation process can be avoided. For this purpose, MTM can contribute with the module ProKon (production-suited construction). During the development and design phase of a production system, MTM can support with the analysis of the correlating processes. By determining influence factors, potentials for optimisation can be recognised early. During the operating phase of a production system, this optimisation can be used within a continuous improvement process (CIP).

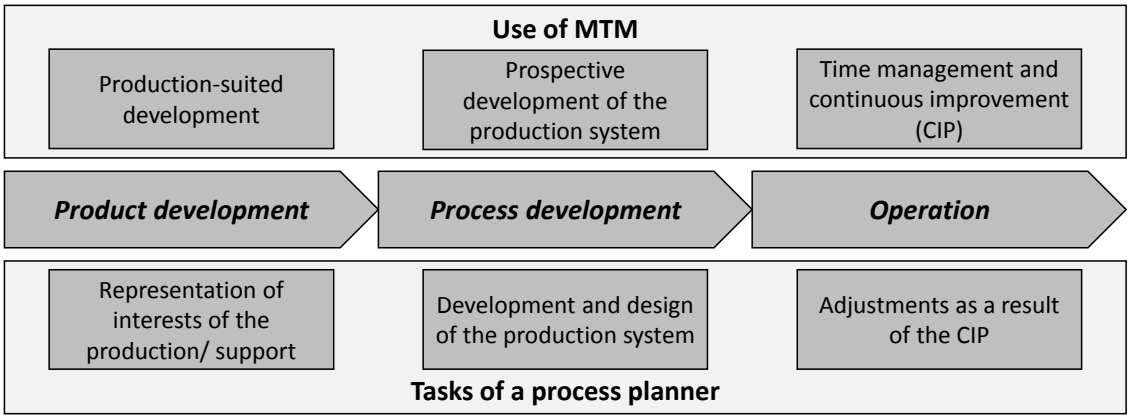

Fig. 1: Use of MTM along the product creation process (following [4])

3. Action-orientated Knowledge transfer in learning factories

The department of human resources development in a company is responsible for all measures concerning the employees' qualification in order to match their abilities with the changing challenges and to improve the company's efficiency [8]. Due to the enormous potentials, a MTM-training is very useful for the qualification of process planners. Practice- and action orientated approaches, such as planning games, were proven to be effective, as those show directly the practical benefit of the knowledge transfer [9, 10]. Nevertheless, those planning games have deficits because of the missing realism, which complicates the transfer to individual operational challenges. On the opposite, trainings close to the workplace can fix this problem, but they are often subjected to the difficult boundary conditions of a running production. Learning factories offer new possibilities, as optimisations can be tested safely and without any cost pressure in a real production environment, which simplifies the knowledge transfer from the training to the own workplace [11,12]. Those advantages lead to the effect that a lot of universities are going to build up more and more learning factories. Due to their globally rising significance, networks have been founded, for example the European Network of Innovative Learning Factories (NIL) [13]. NIL is a project funded by the German Academic Exchange Service (DAAD) to enhance the mobility between the leading European universities involved in research and operation of learning factories. Within this network, an intensive collaboration between the Department of Industrial Engineering in Stellenbosch (South Africa) and the Chair of Production Systems in Bochum (Germany) has been initiated.

4. Concept for trainings in MTM for workplace design in a learning factory

4.1. The Stellenbosch Learning Factory

Realising the potential of Learning Factories, the Industrial Engineering Department at Stellenbosch University, South Africa, has initiated the development of a Learning Factory (SLF) in 2015 for enhancing their undergraduate training offering. This has been done in collaboration with various partners within the NIL network, i.a. the Chair of Production Systems from Bochum.

Using the enterprise architecture model depicted in Figure 1, the SLF has decided to focus on the following primary value chain activities involved in the delivery of products to customers (highlighted in orange in figure 2):

- design activities
- make activities (includes internal operations such as manufacturing and assembly)

This includes internal logistics related to planning, managing and improving the flow of materials/ components/ sub-assemblies/ products.

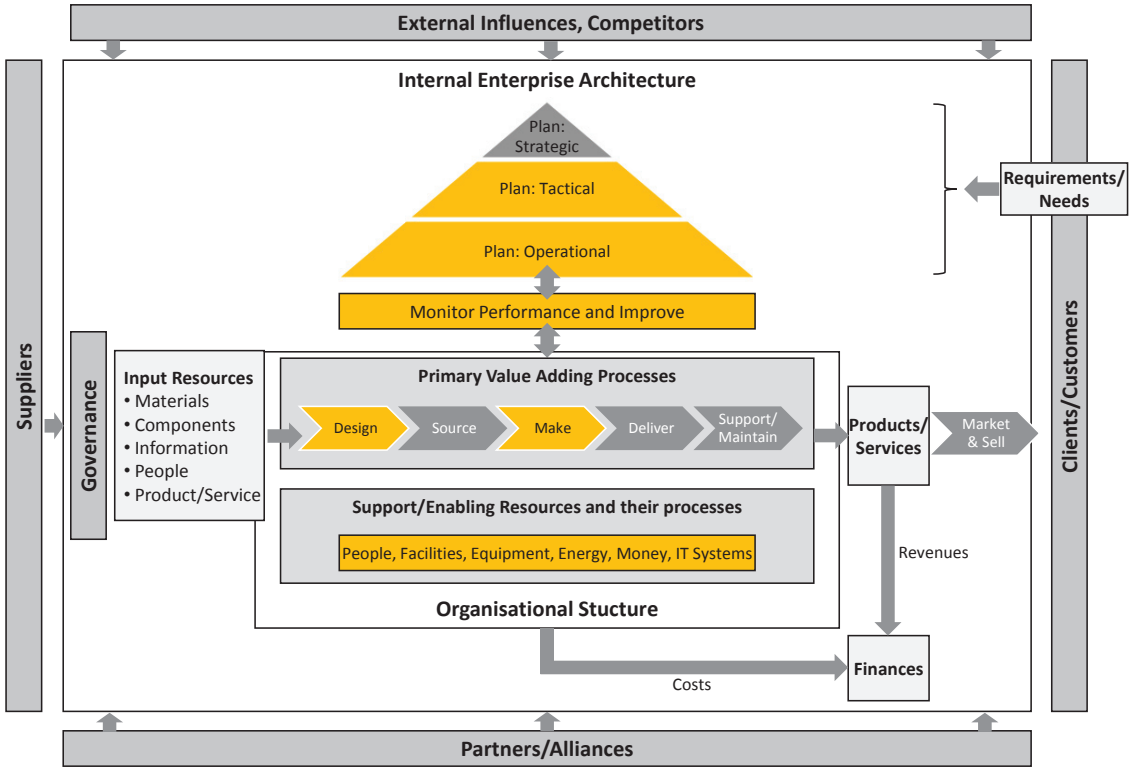

Fig. 2: Enterprise Architecture with SLF scope highlighted

The following items are also included in the scope:

- tactical and operational planning activities required for these primary value chain processes
- performance management activities
- improvement activities
- management of supporting or enabling resources

In 2015, the initial infrastructure in the form of manual assembly workstations as well as storage racks and storage equipment has been implemented. Students were tasked to ergonomically design and construct these workstations and storage racks. A model train (motor coach and passenger coaches) has been chosen and designed as a suitable product to manufacture and assemble in the learning factory. Such trains offer great opportunities and flexibility for teaching different production and production management related concepts.

Before the selection of the product for the SLF, the following requirements were specified for the product:

1. It should have a sufficient number of parts to allow enough complexity for work-flow planning tasks
2. At least two product variants are required to illustrate mixed-model manufacturing and assembly
3. All parts can be assembled and dis-assembled again to allow reuse
4. It should be durable enough to withstand the handling by students
5. The product should provide opportunities for sub-assemblies as well as customisation
6. The product should have an "excitement" factor or appeal for students

Training modules are being developed for the Learning Factory (in areas such as Ergonomics and Workplace Design, Production Management, Manufacturing Systems) to be implemented in their course. The Learning Factory is currently being expanded with additional technologies and equipment to allow automated production cells, tracking and tracing of parts and inventory, as well as visual management tools. The MTM module is to complement those existing training modules.

4.2. Training concept for MTM in the SLF

For each training module, it is decisive to define the main goals, the target group as well as the time frame [14]. The given article focusses on a four-hour training for students concerning MTM in the field of workplace design, considering the model train as the manufactured product. The main goal is to convey knowledge in MTM for the challenges of a process planner, whereas the aspect of time management is intentionally excluded. The target group consists of students in the field of Industrial Engineering.

The training is divided into three main parts, which represent the different categories of Bloom's taxonomy [15]. This taxonomy divides learning goals into the categories knowledge, understanding, application, analysis, synthesis and evaluation [15].

In the beginning, MTM is introduced by a short overview, focusing on the knowledge transfer and the understanding of the application of the method. According to the main goals, the introduction is reduced to the bases of MTM as well as the influence factors with the correlating time values.

The following practical part is divided into five rounds, which are passed by groups of 4-5 students, using the train as the considered product:

1. Watching the assembly of the train
2. Doing the assembly independently
3. Optimising the workplace by means of MTM
4. Doing the assembly at the improved workplace
5. Doing the assembly at the improved workplace of another group

The advantage of the round-based concept is a continuous increase of the complexity on the one hand and the understanding on the other hand. In the first round, the students watch the assembly of the train in a video and derive first ideas of improvements afterwards. In the second round, they experience the assembly on their own by assembling the train at the real workplace. Due to that, they can derive more improvements. While those ideas of the first two rounds are based on intuition, the third round is to optimise the workplace systematically by means of MTM. Therefore, the students receive a complete MTM-1 analysis of the current workplace. Along with the basic knowledge of MTM, the students identify optimisation potentials by a systematic consideration of the impact factors, using tools, like a design checklist, sheet of measures and design catalogues. After implementing the improved workplace, the students try to do the assembly of the train again at the new workplace. By that, they get a realistic feeling of their improvements, which is strengthened in the fifth round by testing the other groups' improvements as well. Thus, the fifth round also serves as an evaluation. During the following reflection phase, the groups present their results to each other. By comparing the own improvements to those of the other groups, the students evaluate their own solution and

get a feeling for better or worse solutions. The final round finishes with a presentation of one possible "best-practice"-solution.

The described training concept focusses on several training goals according to Bloom (figure 3). The theoretical input focusses on knowledge and understanding of the methodological background and the main idea of MTM. While the first two practical rounds serve as a first introduction and are expected to get a feeling for the process, the third and fourth round address the application of MTM by analysing a current workplace and by synthesising a new one. The last round serves as evaluation phase by comparing different solutions.

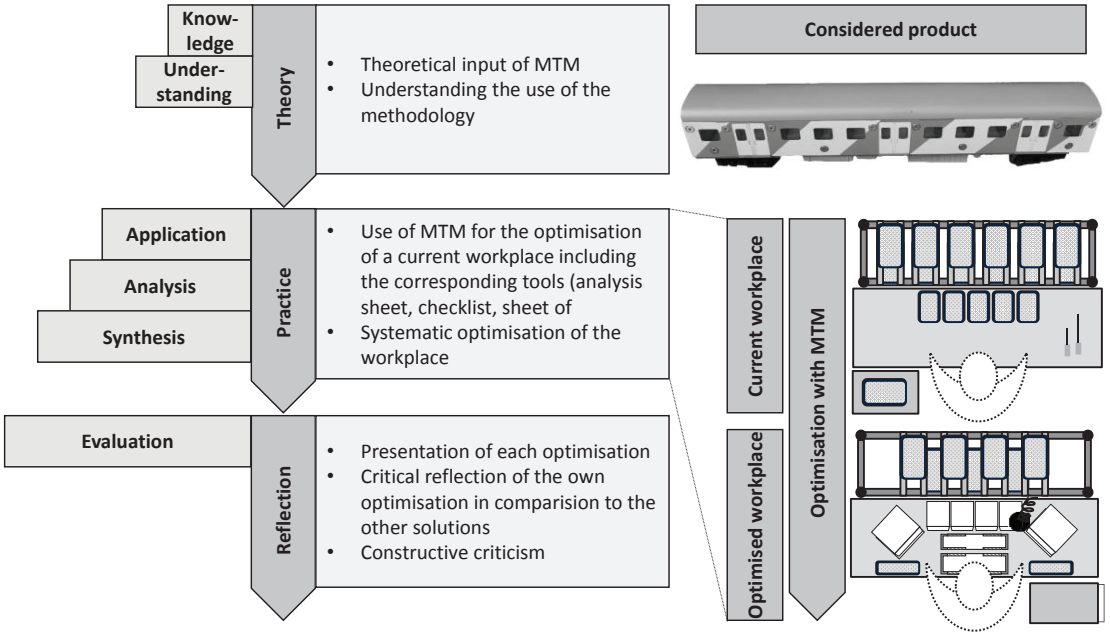

Fig. 3: Training concept for the knowledge transfer of MTM in a learning factory

The training module will be incorporated in the SLF in the first semester Ergonomics course for 4th year Industrial engineering students. The course spans over a 5 months' period and the MTM training will form part of practical training sessions to be completed by the students in groups.

5. Summary

The given article motivates the use of MTM for the process planning of production systems as it allows a systematic analysis and design of manual assembly-workplaces. Especially the application along the product creation process enables a multiple field of applications. As MTM requires intensive trainings and extensive time studies are complicated, many companies avoid the use of MTM. Learning factories offer the possibility to focus on the "workplace-designing-aspect" of MTM and make a practice-orientated knowledge-transfer possible. The time-frame of four hours is sufficient to get a basic understanding of MTM, which is helpful for the design of workplaces. For a further understanding, especially concerning the aspects of time-management, which also plays an important role in industry, a complete qualification in MTM is indispensable.

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