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Implementation of statistics tools in the GrEta mass production modelling environment

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***Abstract**: As a part of our LEGOstics plotting board series we've created the GrEta production simulation. In this creative learning environment all the actions are provided by participants – with flexible, dialectic (learning-by-doing) ways, focusing on evaluation results and the whole process of performance measurements. We are developing all these environments on the same platform: analysing and developing the processes according to the technology and real nature of logistics processes (warehousing, material handling, production and transportation). During the trainings the participants can experience the theory/curriculum of production – push, pull systems, kanban, lean thinking, bottleneck problem etc. In the actual state of the development we are focusing on the quality management. Using statistical tools can help us to see some correlations and contexts between the operations and the created results: the quality of products/services.*

***Keywords:** LEGOstics, GrEta, Quality management, Learning-by-doig.*

1. THE GRETA ENVIRONMENT

GrEta is a self-developed, non-official LEGO product, based on our intention to construct a relatively simple model, which can be built up differently and in totally flexible ways. GrEta car has 8 separate functional parts: chassis, wheels, engine, engine hood, seat, computer unit, cabin, lamps. The parts also can be assembled on several ways. The participants have a lot of possible strategies and production system structures, according to the decisions of the team based on the different personal attributes. The plotting board is basically a regular wooden board, which has been separated into four workstations. Between the workstations we situated four drawers for transportation. In the game the transportation has the highest priority, when a box (shipment) comes it always have to be unloaded and sent back to the previous participant to provide the possibility for the continuous material flow. We also developing an application, which is suitable for measuring the participants's gametime while playing with GrEta plotting board. This automatic time measurement tool can give us information about the participants active/inactive periods, how long does a game lasts, when the drawers move. The software registers the results into a CSV file, where we can easily make graphs, and analysis.[4]

Figure 1. GrEta car [6]

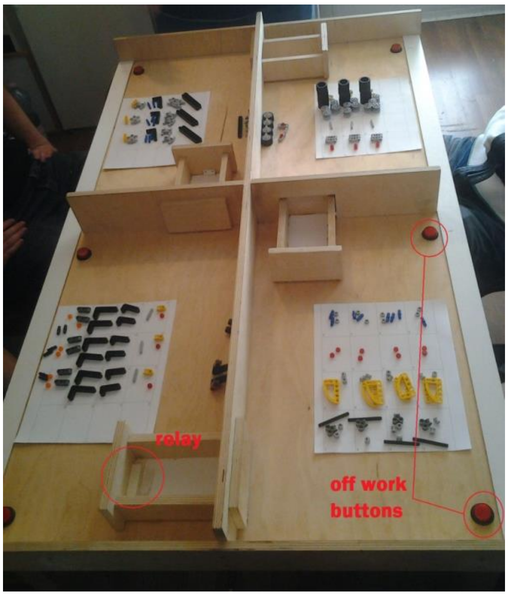

Figure 2. Electric Plotting board [7]

2. QUALITY MANAGEMENT IN GRETA ENVIRONMENT

A quality management system (QMS) can be expressed as the organizational structure, procedures, processes and resources needed to implement quality management. Early systems emphasized predictable outcomes of an industrial product production line, using simple statistics and random sampling. By the 20th century, labour inputs were typically the most costly inputs in most industrialized societies, so focus shifted to team cooperation and dynamics, especially the early signalling of problems via a continuous improvement cycle. In the 21st century, QMS has tended to converge with sustainability and transparency initiatives, as both investor and customer satisfaction and perceived quality is increasingly tied to these factors. Of all QMS regimes, the ISO 9000 family of standards is probably the most widely implemented worldwide - the ISO 19011 audit regime applies to both, and deals with quality and sustainability and their integration.

Quality – why should we study it?

Quality is everyone´s concern – it is a very real part of our daily lives. Leading scholars have recognized the inextricable synergy between organizational *excellence* and *quality;* these two key terms are synonymous. Excellence has been defined as „the overall way of working that balances stakeholder concerns and increases the probability of long-term organizational success through operational, customer-related, financial, and marketplace performance excellence“. Almost everyone would understand the concept of excellence – that is, the merits of striving to be the best – to excel in all walks of life.

The need is apparent. Satisfying that need is perhaps the most compelling reason why you should study this subject. The market for qualified quality professionals is growing and the applicable compensation and benefit packages can secure a comfortable lifestyle. Since quality is about excellence and excellence is about balancing the need of all stakeholders.

From the literature os management sciences we know a lot of different tools used in quality management, for the GrEta environment we chosen six different methods to have an effective tooklit: Brainstorming, Check Sheet, Pareto Chart, Cause-and-Effect Diagram, Histogram, Scatter Diagram.

2.1 Brainstorming and Brainwriting

Structured and unstructured brainstorming is used by groups to verbally generate a large number of new ideas within a short period of time, normally with the use of a group facilitator to keep things moving along in an orderly fashion. When ideas are written down, rather than shared verbally, the technique is called brainwriting. However, the term brainstorming is generically used to refer to either technique.

The difference between structured and unstructured brainstorming/brainwriting is that the former requires each person in turn to contribute an idea when called upon; in the latter case ideas are spontaneous and no one is forced to participate. To be effective the following brainstorming rules of conduct should be followed.

- Free expression, called freewheeling, is encouraged by all,
- All ideas are welcome,
- Criticisms or critiques are strictly forbidden.

We use this tool since we created the training scenario; it’s a really important part of the training to discuss the ideas, experiences, problems and suggestions at the end of each round before we move on with the optimization.

2.2 Check Sheet

Before a problem can be analysed it needs to be understood. A check sheet, normally handwritten form on paper, is used to record raw data in a format that can be easily understood by everyone. In the GrEta environment usually the problems are not material, rather scheduling problems. Therefore on our checklist it's wiser to note the movement what took more time than it should. For that we need to measure all the basic movements of assembly with our measurement tool – Elli3 – for elementary tasks. Based on the results we can create a list and define the frequency of in-time deviations.

2.3 Pareto Chart

The Pareto principle posits that only a few causes (the vital 20%) are responsible for the majority (80%) of problems. Improvement benefits can be leveraged by focusing attention on the key issues (that is, the 20%), and while looking at critical factors this is not uncommon to discover and resolve many of the other lesser important problems by default. When check sheet data are plotted on a Pareto chart, the most important problems are revealed. It is customary to plot a pair of graphs – a bar graph that displays item percentages sorted in descending order, and a line graph that plots the cumulative percentage of items on the sorted list. These two graphs are then plotted on the same chart.

The figure below shows a sample Pareto chart, the problems are divided into 5 categories. This way the significant (vital) problems can be separated from the trivial ones. In this case this is clear that improvement efforts should target problems A, B and C. With this method in GrEta environment we can highlight the *"bottleneck positions"* regarding to the *"bottleneck movements"*.

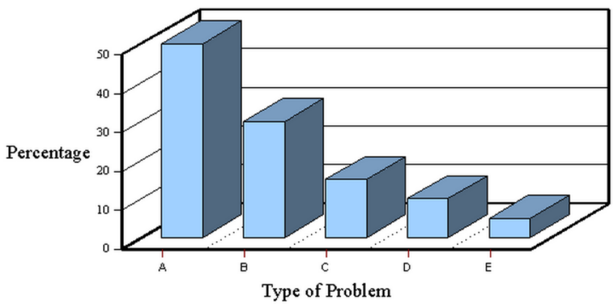

Figure 3. Sample Pareto diagram [3]

2.4 Cause-and-Effect Diagram

The cause-and-effect (CE) diagram is also called a fishbone diagram (due to its similarity to the skeletal structure of a fish), and „*Ishikawa diagram*" (in honour of its founder). Once a team decides which problem it wants to solve, possibly from a Pareto analysis, the CE diagram can help to identify candidate causes.

The CE structure is illustrated in the following figure. To construct a CE diagram, the problem, or effect, is placed in a box. A horizontal line is drawn from the box, and from the backbone angled fishbones are inserted corresponding to each main problem category. This forms the skeleton of the fishbone diagram.

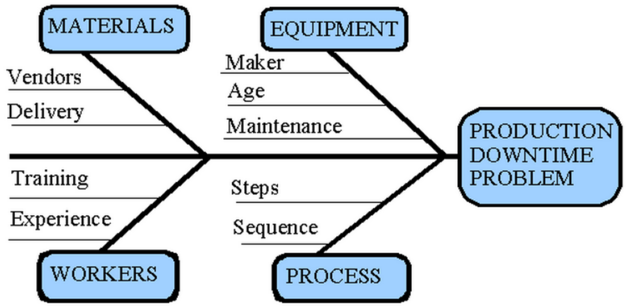

Figure 4. Fishbone Diagram Structure [3]

Main categories can be anything relevant to the problem, but the typical ones include materials, methods, personnel, and machines. From each main item smaller bones are constructed for each candidate cause, and from these, smaller bones representing subcauses are drawn. The diagram can include as many sublevels as required to get to the root causes.

For example in the GrEta environment we can consider the "Process" box as the production in push system. The smaller bones can be the delays and idle time. Going deeper we can realise, if a position doesn't have enough time to prepare its task before the next product comes, it would cause a bottleneck, and the whole process will stop, gets wrecked. With applying a controversial system (pull) the positions get the next semi-finished products when they are prepared for them so that the process can go seamlessly.

2.5 Histogram

A histogram provides a graphical picture of process output. Collecting raw measurements is meaningless unless the data can be organized in a way that aids discovery and analysis.

In our case we can measure the time between finishing the complete cars, or different operations, then classify them. That way we can see the dispersion of operations' time consumption.

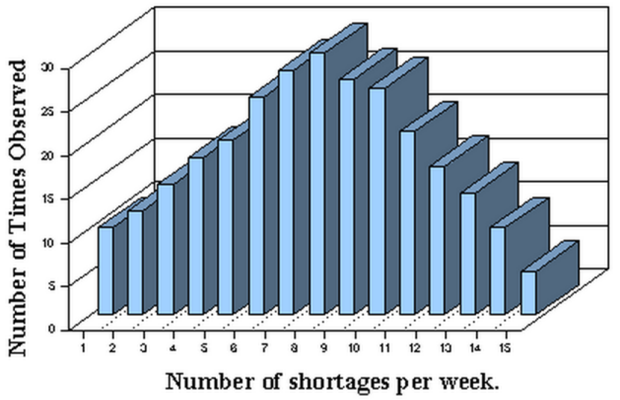

Figure 5. Sample Histogram – how performance measurement is distributed over time [3]

To construct this histogram, each of the data points should be assigned to class intervals. A bar chart can be then constructed by plotting the frequencies calculated in each class interval. The histogram provides an approximate picture of the process distribution.

2.6 Scatter Diagram

Like histograms, scatter diagrams aid in pattern recognition. A scatter diagram, also called a scatterplott, can be used to gain insights into the relationship between two factors. If a relationship is found, it cannot necessarily be inferred that one variable is the cause of the other; however, the scatter diagram can provide graphical evidence that the relationship is real and will provide some knowledge regarding the strength of the relationship.

A scatter diagram is constructed by plotting the values of one variable on the horizontal (x) axis, and the corresponding value of the other variable on the vertical (y) axis. A relationship between the two variables is evident if the resulting plot produces some non-random pattern of points. The strength of the relationship is determined by the variability of the cluster of points relative to a mathematical expression describing the association. A relationship can be linear or nonlinear.

The following figures illustrate some scatter diagrams that are linear, and below some nonlinear relationships.[1]

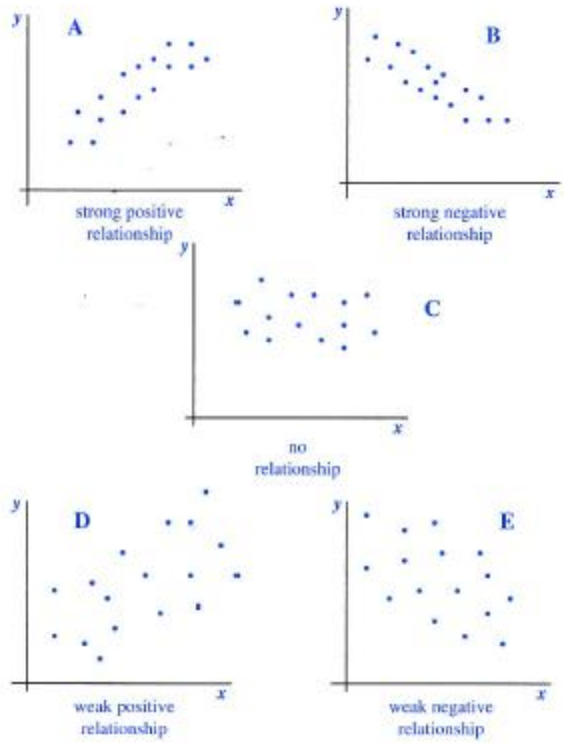

Figure 6. Linear relationships [1]

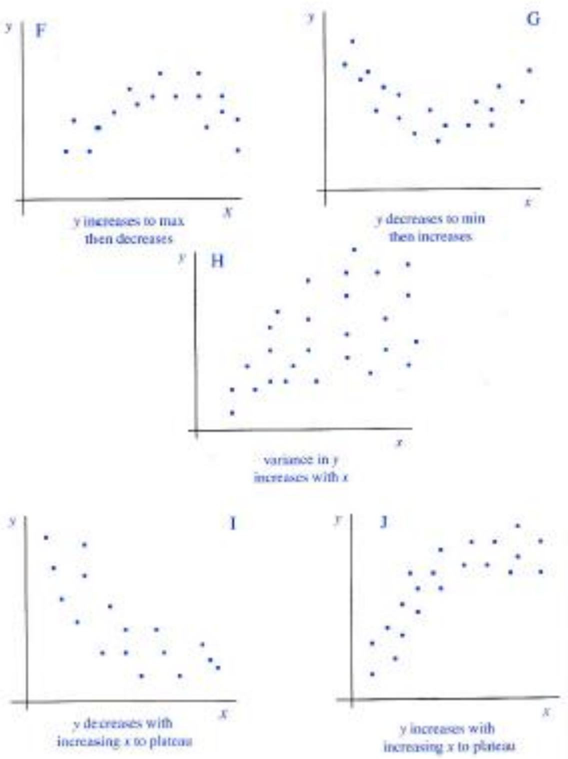

Figure 7. Nonlinear relationships [1]

3. CONCLUSION

We have lots of experience about the trainings, measurements and evaluation. The test results show that the developed automatic time measurement program is necessary and effective, on this way it is possible to log many state-variables. Participants can learn easily how a mass production system is working, and they can develop critical skills according to the preparation of decision making processes, negotiations, logistics process measurement and evaluation.

In spite of the fact that GrEta is a classical factory-type environment, it is possible to extend it on the supply chain context with defining specific lead times and order batches for material supply (box movements). Although experts consider logistics operates within one corporation and supply chain management deals with the collaboration of separate corporations from our point of view these are not completely different fields. The synchronised, well balanced production processes are equally important as synchronised and well balanced supply relations. The methods we present for production planning in the frame of the trainings are also capable to demonstrate the interactions in the supply chains.

During the training it is possible to put emphasis on the importance of logistics process re-engineering and develop the critical skills of participants to be able to:

- recognize critical factors of production
- construct appropriate performance measurement systems
- support the decision making process of system developments

In our paper we presented a possible way to teach and understand quality management and some sophisticated statistical tools to develop a well-balanced production environment.

4. ACKNOWLEDGEMENT

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