

Implementing QR-codes for tracking the material flow in the Trudi LEGOstics environment

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Abstract

The Trudi LEGOstics plotting board was constructed for modelling the material supply and assembling processes of a car manufacturer supplier company. In the frame of the continuous development of this special mass-production system at Szabó-Szoba R&D Laboratory many additional functions came into focus, like bottleneck problem analysis approach, work-in-process inventory management viewpoint, lean production methods, etc.

Implementing QR-codes on the boxes and using tablets for reading at each workstation forms the basis of material flow tracking. It is possible to derive the tact-time of operations from the results, and on this way we can build up a systematic and coherent inventory management and performance measurement system.

Index Terms— production processes modelling, QR-codes, tracking

Content:

INTRODUCTION	4
LEGOSTICS.....	4
THE TRUDI ENVIRONMENT	5
OPERATORS AND TASKS.....	6
PREPARATION FOR IMPLEMENTATION – CREATE A LEGOSTICS CLASSROOM .	8
SCENARIO OF A LESSON	9
PROCESS DEVELOPMENT DURING A LESSON	12
EXPERIENCES DURING THE LESSONS.....	13
FURTHER DIRECTIONS OF DEVELOPMENT IN TRUDI MODELL	14
QR CODES IN THE SYSTEM.....	15
IT BACKGROUND.....	16
CONCLUSION.....	17
REFERENCES	17

INTRODUCTION

The main challenges of modern logistics and supply chain management are providing high level quality service for customers according to the ever-growing and ever-changing demands, optimizing low series production and distribution in various environments, managing stocks in lean and agile production systems, eliminating the bullwhip effect, applying different trade-off solutions for minimizing infrastructure investment, distribution and warehousing costs and maximizing capacity utilization (BAJOR, BÓDIS, MAKRAI 2011).

The wide variety of products, the challenges of fluctuating demand, the appropriate inventory management and the application of modern production and distribution strategies requires flexible innovative thinking and special management skills from experts: to construct and manage an effective, well-balanced manufacturing and distribution process in supply networks.

Nowadays it is not possible to teach all the solutions of some problems to managers and engineers, so they have to be familiar with problem solving methods. Furthermore we believe that the only way is the learning by doing method to understand how logistics works.

LEGOSTICS

The collective noun LEGOstics is coming from the LEGO and LOGISTICS words: LEGO products are very suitable for modelling such semi-virtual (in most cases non-semi, but real) logistics environments. The bricks and parts are very popular around the world, usually they are considered as high quality innovative products to help in development of constructive skills – from childhood to being a parent, and after. It is important to highlight that we are using these products in totally new applications, new forms like planned by the producer. What is really innovative in LEGOstics Laboratory: “How to use?”, not “Which type of products to use?”, so in our environments we can use also metal construction boards or any other wood-bricks – the reason why LEGO products were chosen was: the students are very familiar with, and these environments are also “mobile” applications, we can bring them to several formal and non-formal education situations and special circumstances (the first successful DotSCan application was provided in a prison for training prisoners becoming warehouse assistants).

We are developing all these environments on the same platform: analyzing and developing the processes according to the technology and real nature of logistics processes (warehousing, material handling, production and transportation, etc.)

THE TRUDI ENVIRONMENT

The Trudi LEGOstics plotting board initially was constructed to help in the selection of new employees at a car manufacturer company – the continuous development of this special mass-production system in Szabó-Szoba Laboratory brought many additional functions, like bottleneck problem analysis approach, work-in-process inventory management viewpoint, lean philosophy implementation problems, etc. In our essay we present The Trudi LEGOstics environment in operation, analyze the available results, and give some perspectives of prospected measurements and additional functions.

The plotting board is separated for 4 parts as work stations, each sector has an operator. The 4 types of players as system operators are: Picking, Parts assembling, Final assembling, Disassembling and selection. The system architecture is modular and convertible. The materials easily flow across the workstations. The shelving system is infinitely variable and can be placed everywhere on the table. Between the work places we use boxes for material handling.

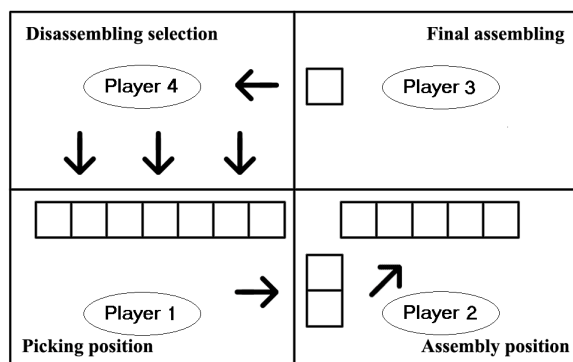


Figure 1: Trudi layout, LEGOstics in education

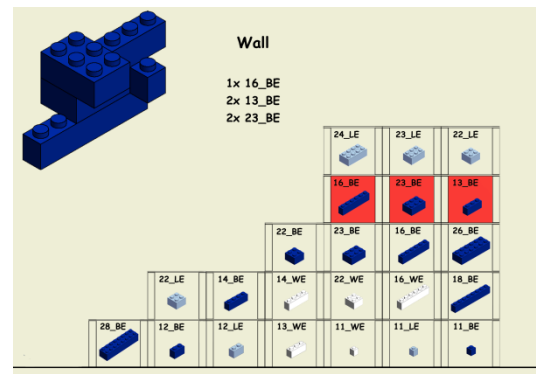
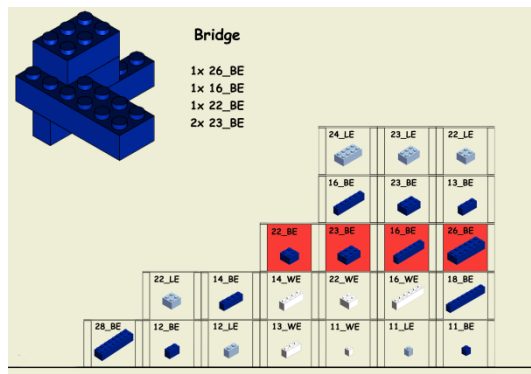
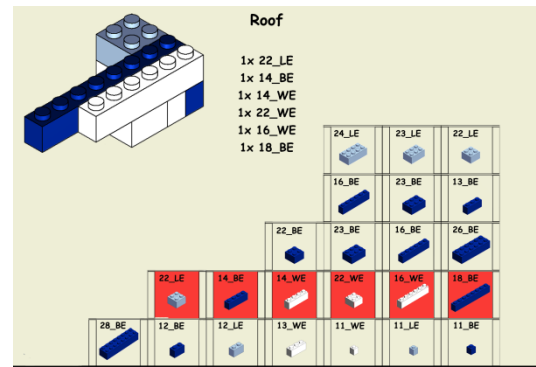
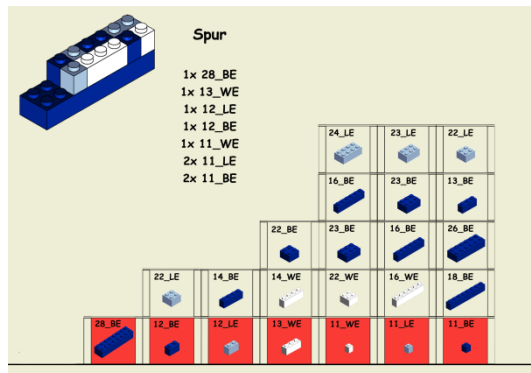
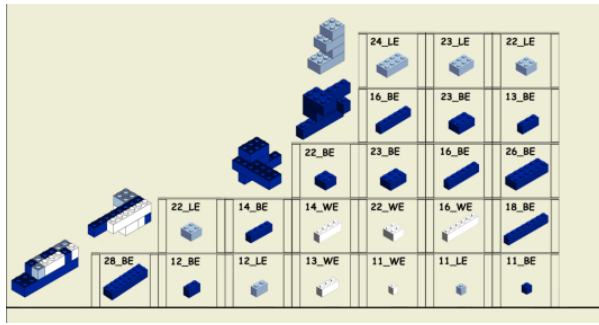


Figure 2: The warehouse structure from the order picking side

OPERATORS AND TASKS

Order picker (Player 1) is picking the components to the boxes and the boxes are passed to the component assembler (Player 2). To avoid the errors the boxes should be labeled to know which elements should be picked more than one times (the same devices to many parts). Between the order-picker and the parts assembler has a puffer with double position for each unit load to get enough places and spares. As we planned, the process is driven by this visual kanban system. In this warehouse structure all the subset has two seats. It is important to label shelves to know

which elements on the shelves and to be able to recognize the needs easily. Because if Player 1 gives a lot of the same elements to the parts assembler and just make one part then the production will stop after a while because the final assembler just has the same parts.

Assembly worker assembles the components and pass them to the final assembler position. Player 2 receives the components from the picking boxes, and removes the parts from the box. When Player 3 puts back the box on the right place, it is a calling sign for the order picking operator. If Player 3 is working too slowly, it can cause problems in the production. For example can accumulate the stocks in the warehouse between the picking position and the assembling position, and the final assembling are waiting for the parts to finish the model.

If Player 3 is working too fast makes it difficult to work for the order picker and the final assembler.

Player 3 operator assembles the elements what arrived in parts, and passes the finished product to Player 4 (disassembling and selection) position. If Player 4 can't get the right parts from Player 3 she cannot make the final assembling. If there is no finished product in the process after a while it will not be parts in the boxes between first and second position therefore the production will stop.

Player 4 (disassembling and selection) operator fulfills the warehouse: receives the final production, dismantles it, and put the parts in the right boxes in the warehouse.

The warehouse system on the left has a time-saving layout. Each component has its own line, and each subset has its own box in a warehouse. If Player 4 put a wrong box the subset it can cause a problem, because the next person will picking the wrong subset and put it in the production process. In order to avoid these boxes must be labeled.

Measurement of logistics performance is one of the critical factors for being able to develop a well balanced supply chain. It is possible to measure the tact-time of each operator, and build up a systematic and coherent performance measurement system. We realized that it's not enough to synchronise the different processes based on their time requests. It's a possible direction of

development and new results can come if we apply bar-codes or QR-codes on the boxes – so we can automatically monitor the products and performance of the operators during the process.

As concluded during the trainings, LEGOstics simulations have many promising insights for scientific research – as we can highlight:

- Inventory management
 - Bullwhip-effect,
 - WIP inventory problems,
 - Order Policy,
 - Outsourcing: Make or Buy decisions
- Production system re-engineering
 - MRP,
 - JIT,
 - KANBAN,
 - Lean thinking (different colors of product – parts can stay in the same box!)

PREPARATION FOR IMPLEMENTATION – CREATE A LEGOSTICS CLASSROOM

Our goal was to implement the LEGOstics method into the formal education in the frame of an international collaboration between the Széchenyi István University (Győr, Hungary) and the Technical University of Cartagena (Spain).

The Universidad Politécnica de Cartagena (UPCT) provided the classroom and the necessary equipments. For the first step the interactive environment was created where we prepared the plotting boards and elaborated the course of the trainings together with the teachers of UPCT and a couple of UPCT students.

When everything was prepared (trainings, trainers, and infrastructure) we integrate the LEGOstics trainings into the schedule supplementing the theoretical teaching with some practical aspects.

The LEGOstics method was implemented in the formal education from first grade of Bachelor and final grade of Master level. In that period in Spain there were more than 20 trainings, with the participation of about 100 students. We experienced that the students were really motivated to learn the logistics phenomena in practice; they were opened for collaboration and communication.

When the students made the Trudi part of the class, they discussed more. It was a great experience, than the operators concluded the importance of real-time communication during the process. The biggest problems were, that in the plotting board the boxes has fixed place, but they wanted to send the boxes also with the items. The visual guides gave them an inevitable help during the game.

SCENARIO OF A LESSON

The lessons start with a short introduction about the learning-by-doing method and the LEGOstics theory, presenting the plotting board, the processes, what the trainings are representing. Later, the participants start the simulation.

During the trainings students discuss their experiences round-by-round, they describe the problems appeared. They have to make decisions and search for possible solutions.

On each lessons the trainers or some voluntary observers filled the report; all data of the processes (time, ideas, and problems) was registered.

On the trainings – coordinated by a couple of rules – everything depends on the students, how they organize the working processes, arrange the layouts, assign the time and allocate the tasks.

According to individual skills the bottleneck can appear at different work stations, they can get the experience about the mechanism of push and pull systems this way. There is no need for central control, the process automates itself. The operators have to communicate and collaborate, they can use visual signs to help each other and handle the system.

The steps of the Trudi training are the following:

- Presenting the work stations tasks (selection, order picking, assembling, disassembling)
- Assembly and disassembly the whole model approximately 4 times
- Assembly and disassembly the parts, approximately 4 times
- Playing one or two sample round, being familiar with the process
- Discussion:
 - Expectations, estimations
 - Discussion, change the process 2x, observations, documentations (change – actors? Tasks? Flow?) - shifting to neighbors, - re-organize
 - Homework: presentation
- Evaluating, optimization
 - Courting and standardizing
 - Assembling again
 - New problems
 - Recognition and identification
 - Solutions
 - Round by round optimization
 - Assembling
 - Continuous manufacturing
- Measure
 - Measuring: finish 1st, 2nd, 3rd ... model
 - Workstation finish one task time
 - Transport events/does priority work?
- Evaluation of the results
 - Recognize problems - alternative solutions - making decisions

During the game, put out, or put in 1-2-3-4-5 Trudi from the system, easier to indicate the bottleneck, and the shortage problems

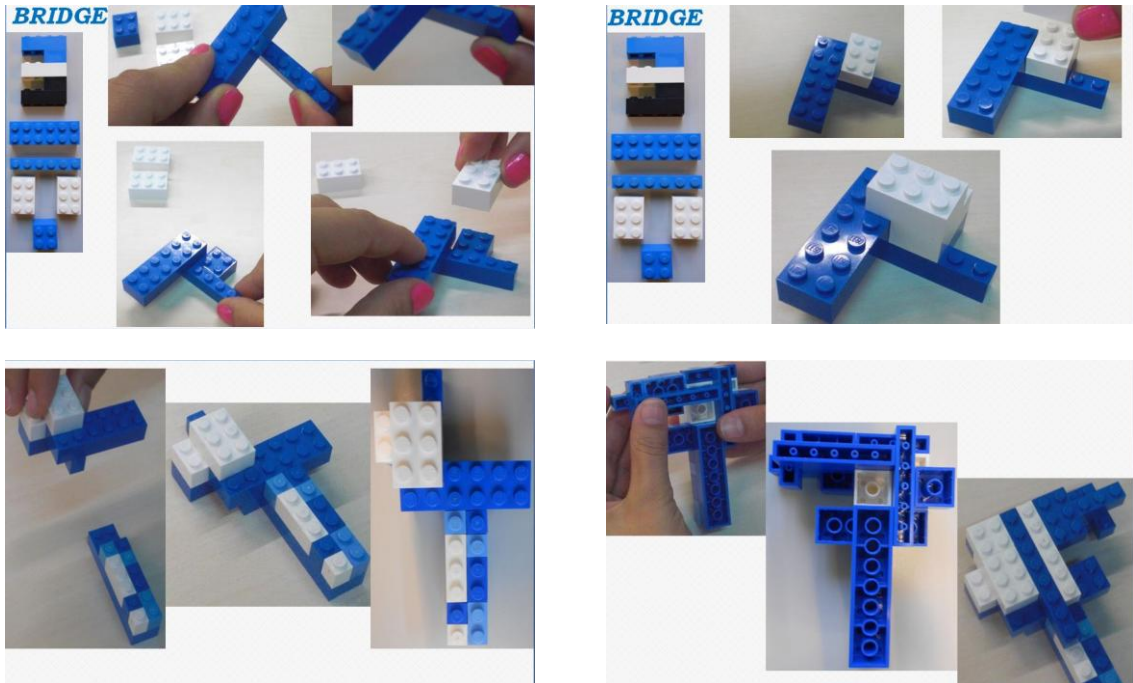


Figure 3: Assembling and disassembling the Trudi model

We realized in the beginning, that participants have to be familiar with the model perfectly for the fluent game, and the experiences shown that about four times assembling and disassembling is enough to get this level. In the first round couple of people got a little bit lost in the processes and the different workstations tasks. After the second round participants were able to follow the tasks and follow the processes.

PROCESS DEVELOPMENT DURING A LESSON

With the predetermined layout

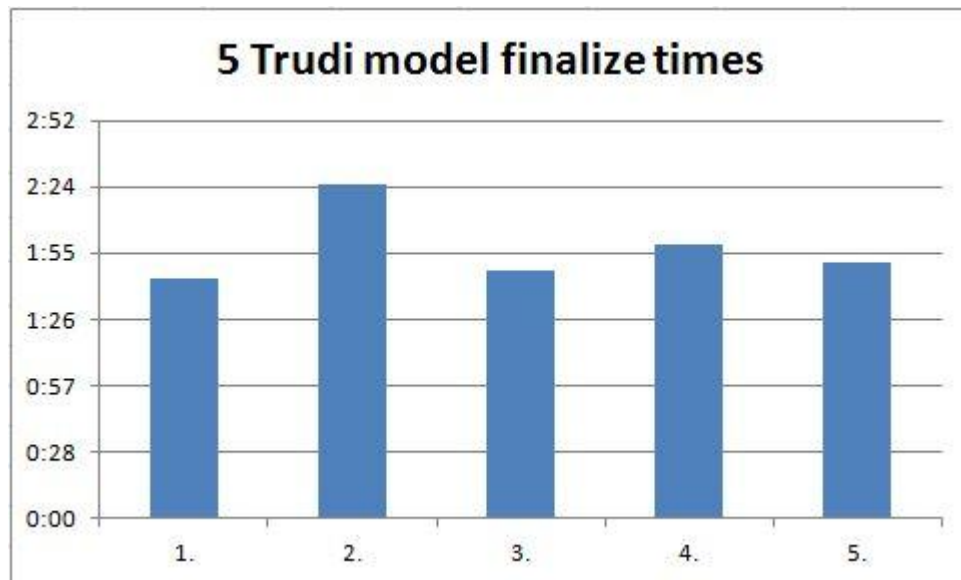


Figure 4: 5 Trudi model final assembly graph

After we measured the time they decided to change the layout, because the assembling worker has been overloaded. So they took the Wall and the Prop from her to the final assembler. After the changes the results were the following:

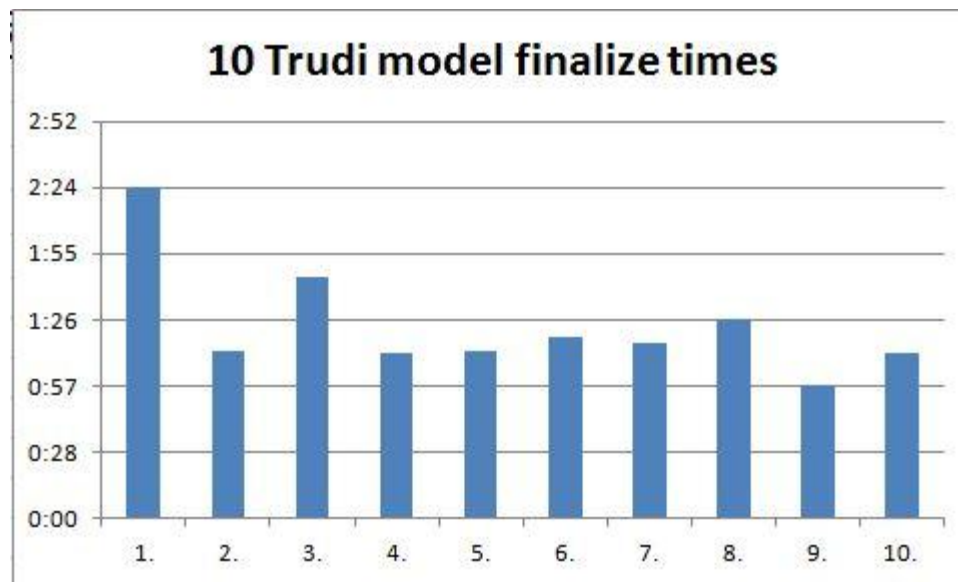


Figure 5: 10 Trudi model final assembly graph

So they changed the warehouse layout, they put a puffer between the final assembler and disassembler. So the disassembler was selected the wall and prop parts directly to the puffer what is in his left side, and the final assembler was picking this parts and assemble the wall and prop. This change increased the performance of the whole process.

EXPERIENCES DURING THE LESSONS

The students enjoyed the trainings, they were interested about every aspects of it, and they made a huge effort to reach better result in the games. They communicated and worked together, so in this way they were able to optimize the processes. We asked them to write down in some words, or sentence what they think about the lesson. So we get a lot of feedbacks like: „It was useful to cooperate and organize”, „this is better than just listening”, „Nice method”, „It was a very useful practice”, „it was very instructive”.

Generally the students said they had a good time, during, and after lessons. They told us it was very interesting to utilize in practice what they learned in the courses about different logistics processes, and most of the times it's better to see and experience theoretical things in practice.

They also told that in this way, they can understand better the importance of communication and process optimization.

The observers measured the time, but the administration was not sufficient. First we just gave them a paper to register the times, but it was not in the manageable form for analysis. We made a documentation form and their task got easier, just fulfilling it - than discussion of results got faster.

FURTHER DIRECTIONS OF DEVELOPMENT IN TRUDI MODELL

Next stage of development in the Trudi plotting board is automatic measurement and tracking of processes (measurement with informatics support). On the trainings we realized that registering the details of the processes may get too complicated. Using some electronic devices can be an effective solution: the electronic devices with the proper programs can collect and analyze the data from this LEGOstics environment.

The bests are barcodes or QR codes. The QR code can store more data and easier to read it. So we chose to use tablets, because it has the features we need: a camera, being mobile, with rechargeable batteries, appropriate screen, input possibilities, and a proper operation system, software for reading QR codes and collect the data. We will put the codes to the boxes of Trudi, and use the tablet to read them, during the game. The software will save the time of reading, and the code of the item. It will be saved to the memory, in a .csv file, we can export for further use. The operator's task consists only two easy steps: first read the codes, than save. Using tablets in Trudi model, is brake with the paper base administration, and give the participants a new thinking method in the 21st century. This idea makes easier, faster to collect data from the system; furthermore it makes the game more interesting and modern. In this way the model will be more similar to the nowadays warehouse systems, and we can measure the performance very efficiently.

QR CODES IN THE SYSTEM

We will put the codes on the boxes. Every box will get one QR code with the data what the box contain, in this case we are able to measure every box movements, and the inventory level in the warehouse. There will be another QR code on each workstation to measure when they are ready with one task, and when they start the other. This code is just an I/O sign and the reader will put a time stamp next to it. Every item (LEGO bricks) will get a QR code, and with this we can see one product way during the game.

We will read the codes during the whole game time, and we will administrate every steps in the warehouse and the assembly area also at the same time. All of the administrative tasks will be semi-automatic, and we can get the data in an digital file, what is help us a lot to work with it, and make conclusion for optimization

We will get the results about everything what happened during the game.. In this case we will able to see where the bottleneck is in the system, we can see the inventory level, demand, and shortage also. With the data what we get from bricks QR code read, we will see, how much time need for one item to goes through the system, how much time it spend in the warehouse, and in the different positions.

IT BACKGROUND

- Android based application
- Two types of input methods
 - Identify a specific element (component, parts, box, etc.)
 - Reading a QR-code placed on that element
 - Give the quantity of something
- The process
 - Order Picking
 - Read the code of the component (semi-finished product) for which the parts are picked
 - Show the list of parts with quantities
 - Read the code of the box of the part (LEGO bricks)
 - When finished, read the code of the box where the picked parts are put in
 - Production
 - Read the code of the component started to produce
 - Read the box of the picked parts
 - When finished, read the code of the box the assembled component is put in
 - Final Assembling
 - Read the code of the product when start to produce
 - When finished, read the box dedicated to the final product
 - Disassembling
 - Read the code of the box where is the final product
 - At every store-in events, read the QR-code of the part
 - Give the quantity stored-in of that part

CONCLUSION

We will use electronic devices and QR codes in the system, because the students can learn how to make decisions, and how to realize the problems and also how react them, but at the same time, they should know use the modern equipments, handle them, understand their working method. After they have to learn analyze the data what they get, and make develops with the data and real life experiences what they can get during the lessons.

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