ABOUT THE AUTHORS

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- Professor of Supply Chain and Operations Strategy at Kühne Logistics University since 2012
- Ass. Prof. at University of Cologne, visiting scholar at National University of Singapore, Cornell University and Israel Institute of Technology,
- Project manager and strategy consultant at Booz & Company in the Operations Practice
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- Ph.D. student at the Kühne Logistics University since 2012
- Diploma degree in Business Administration from University of Cologne with majors in Supply Chain Management, Transport Economics and Finance
- Internships with OSCAR GmbH, Bayer MaterialScience AG and DB Schenker AG in Germany and Indonesia

Inspired by Prof. John J. Bartholdi, III, Georgia Institute of Technology and M. Amirhosseini, UPS Worldwide Logistics

Please feel free to contact us directly for any questions or improvement comments
AGENDA

- Introduction
  - Instructor Preparation
  - Student Preparation Hand-Out
  - In-Game Hand-Out
  - Other Material
LEARNING OBJECTIVES AND APPROACH

Objectives
1. Experience some of the challenges of balancing work when customer orders are picked progressively.
2. Understand the principle of “self-organizing systems”
3. Compare the performance of bucket brigades to performance of alternative ways of organizing workers

Approach
1. The game features an assembly line for order-picking.
2. Orders consist of different items (Lego bricks) from 15 different locations

Benefits
1. Demonstrate the effectiveness of bucket brigade in assembly lines
2. Understand the principle of “self-organizing systems”
3. Enables students to easily grasp the concept of bucket brigade with help of this simple hands-on simulation
GAME HIGHLIGHTS AND STUDENT FEEDBACK

“I understood that bucket brigades are simple to be set up and efficient at the same time”

“I now know the benefits of self-organizing systems”

“High utilization of all workers is the key for efficient production processes”
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The picking Lego game simulates an assembly line for order picking. Students will be responsible to fulfill orders by picking items from various storage locations.

Three students are assigned to pick Lego bricks from 15 plastic buckets representing storage locations. The objective is to fulfill as much orders as possible (in the right sequence is a plus).

One student is allowed to use his hand to pick the items, one wears a glove and one uses chopsticks. The purpose is to simulate workers with different productivity.

In round 1 the three students get an order, finish it by picking all items by themselves and start over with another order. They can move independently in the setup.
In round 2 the assembly line is divided into three zones.
Zone 1 = Location 1–5, Zone 2 = Location 6–10 & Zone 3 = Location 11–15

To complete an order, items must be picked from all three zones. Orders flow from Zone 1 to Zone 3.

Zone 1 features the glove-picker, Zone 2 is under responsibility of the chopstick-picker while items of Zone 3 can be picked by hand. That means zone 2 is the obvious bottleneck.
Workers are free to move as far forward or as far back as they must, subject only to the restriction that they must remain in strict sequence of slowest-to-fastest.

Begin by placing all the workers immediately before location (cup) 1. On signal, the fastest worker takes a customer order and begins picking. As soon thereafter as possible, the second fastest worker takes the next customer order and then the slowest worker starts.

Whenever the fastest finishes an order (reaches the right end of the line), he leaves it and walks back to take over the work of his predecessor, who walks back and so on, until the first worker walks back to start a new product.
<table>
<thead>
<tr>
<th>Round</th>
<th>Setup</th>
<th>Rationale for Round</th>
<th>Expected Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Free picking</td>
<td>• Understanding of the game&lt;br&gt;• Demonstration of the simplest method for order-picking</td>
<td>• Workers will get in each other’s way&lt;br&gt;• Orders will be finished in a sequence other than they were released</td>
</tr>
<tr>
<td>2</td>
<td>Zone-picking</td>
<td>• Understanding of zone-picking&lt;br&gt;• Demonstration of situations with different productive employees&lt;br&gt;• Build-up of WIP inventory due to the bottleneck of the chopstick-picker, while the hand-picker is barely utilized</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Discussion &amp; Introduction to Bucket Brigade</td>
<td>• Motivate students to think about solutions and develop a strategy for performance optimization</td>
<td>• Discussion and formulation of the main problem</td>
</tr>
<tr>
<td>3</td>
<td>Bucket Brigade</td>
<td>• Understanding of self-organizing systems especially of bucket brigade</td>
<td>• Best performance of all rounds&lt;br&gt;• 100% utilization&lt;br&gt;• Orders finished fast and in the correct sequence</td>
</tr>
<tr>
<td></td>
<td>Debriefing</td>
<td>• Reflection of learning objectives to ensure memorization&lt;br&gt;• Demonstration of best-practices</td>
<td>• Full understanding of the bucket brigade principle and assembly line organization</td>
</tr>
</tbody>
</table>
## PROPOSED TEACHING TIME LINE

<table>
<thead>
<tr>
<th>#</th>
<th>Task</th>
<th>Estimated Timeline</th>
<th>Duration of Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>(Print of hand-outs &amp; order sheets)</td>
<td>(10 min)</td>
<td>(10 min)</td>
</tr>
<tr>
<td>1</td>
<td>Preparation and setup of assembly line</td>
<td>0 – 5 min</td>
<td>5 min</td>
</tr>
<tr>
<td>2</td>
<td>Introduction to students, explanation of rules, setup, tasks &amp; equipment, answering questions</td>
<td>5 – 15 min</td>
<td>10 min</td>
</tr>
<tr>
<td>3</td>
<td>Round 1</td>
<td>15 – 20 min</td>
<td>5 min</td>
</tr>
<tr>
<td>4</td>
<td>Count of fulfilled orders and check of sequence</td>
<td>20 – 22 min</td>
<td>2 min</td>
</tr>
<tr>
<td>5</td>
<td>Round 2</td>
<td>22 – 27 min</td>
<td>5 min</td>
</tr>
<tr>
<td>6</td>
<td>Count of fulfilled orders and check of sequence</td>
<td>27 – 29 min</td>
<td>2 min</td>
</tr>
<tr>
<td>7</td>
<td>Discussion</td>
<td>29 – 39 min</td>
<td>10 min</td>
</tr>
<tr>
<td>8</td>
<td>Round 3</td>
<td>39 – 44 min</td>
<td>5 min</td>
</tr>
<tr>
<td>9</td>
<td>Count of fulfilled orders and check of sequence</td>
<td>44 – 46 min</td>
<td>2 min</td>
</tr>
<tr>
<td>10</td>
<td>Debriefing</td>
<td>46 – 51 min</td>
<td>15 min</td>
</tr>
<tr>
<td>11</td>
<td>Optional Session on assembly lines &amp; self-organizing systems</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
OVERALL SEQUENCE OF EVENTS

- **Round 1**: Production (min 1-5)
- **Round 2**: Production (min 1-5)
- **Bucket Brigade Discussion**: Discussion of bucket brigade and explanation of new setup
- **Round 3**: Production (min 1-5)
- **Debriefing**: Discussion of learnings

- **Start of Round**
- **Count of completed orders and check of sequence**

**Legend**:
- Production
- Processing and reflection
WHAT TO PREPARE AND TO BRING ...

Necessary Equipment

300 x

24 x

1 x

1 x

1 x*

* Please find order print-outs at the end of this presentation
TASKS OF THE INSTRUCTOR FOR RUNNING THE GAME 1/2

- Select an appropriate room with sufficient space for “manufacturing operations”.

- Print-out order sheets.

- Use the felt-tip marker to label the plastic cups clearly 1 through 15 and set them up in sequence along a table. Each cup is a storage location from which items will be picked.

- Put a handful of Lego bricks in each cup. These will be the items to be picked.

- Place the stack of customer orders to one side of location (cup) #1.

- Pick three students to be order-pickers and give each a cup in which to carry Lego bricks.
TASKS OF THE INSTRUCTOR FOR RUNNING THE GAME 2/2

- Make sure that the student who uses the chopsticks is not a frequent chopstick-eater. Otherwise the intention of him being the slowest picker could be disturbed.

- **DO NOT** allow use of personal pliers or chopsticks.

- Be strict about the time.

- Have discussions with the class while the game is running to ensure attention.
SAMPLE QUESTIONS FOR DISCUSSION

“What is the reason for your poor performance?”

“How would you be able to speed up order-picking?”

“Who should be criticized for the performance issues?”

“What do you need to change in your assembly line?”

“Can you imagine what “bucket brigade” could mean?”
SAMPLE QUESTIONS FOR DEBRIEFING

“What did you learn today?”

“How about increased cost from the coloring step?”

“Could you explain the key characteristics of bucket brigade to others after this session?”

“Do you know which companies have been using bucket-brigade?”

“Which kind of production lines should consider using bucket-brigade?”

“How about increased cost from the coloring step?”

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YOU WILL MANAGE AN ASSEMBLY LINE FOR ORDER PICKING

Assembly Line Setup & Rules – Round 1

- The picking Lego game simulates an assembly line for order picking. Three of you will be responsible to fulfill orders by picking Lego bricks from 15 different storage locations for 5 minutes.
- One of you is allowed to use his hand to pick the items, one wears a glove and one uses chopsticks. The purpose is to simulate workers with different productivity.
- **Round 1**: Everyone of you gets an order. Finish it by picking all items on the order sheet and start over with another order. You can move independently in the setup.
In round 2 the assembly line is divided into three zones.
Zone 1 = Location 1–5, Zone 2 = Location 6–10 & Zone 3 = Location 11–15

To complete an order, items must be picked from all three zones. Orders flow from Zone 1 to Zone 3.

Zone 1 features the glove-picker, Zone 2 is under responsibility of the chopstick-picker while items of Zone 3 can be picked by hand. That means Zone 2 is the obvious bottleneck.
ALL SPECTATORS SHOULD WATCH CAREFULLY AND TAKE NOTES

- Watch out for the utilization and waiting times of each worker.

- Watch out for the bottleneck and the status of WIP-inventory.

- Watch out if the sequence of the completed orders matches the sequence of the orders released.

- Watch out for all kind of problems and disturbances.
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## LET’S DO SOME BRAINSTORMING HOW TO OPTIMIZE THE ASSEMBLY LINE

<table>
<thead>
<tr>
<th>Key Problems</th>
<th>Improvement Levels</th>
</tr>
</thead>
</table>

**HAND-OUT AFTER ROUND 2**
LET’S TRY BUCKET BRIGADE IN ROUND 3

Assembly Line Setup – Round 3

- You are free to move as far forward or as far back as you must, subject only to the restriction that you must remain in strict sequence of slowest-to-fastest.
- You begin all in front of location 1. On signal, the fastest worker takes a customer order and begins picking. As soon as possible, the second fastest worker takes the next customer order and then the slowest worker starts.
- Whenever the fastest finishes an order (reaches the right end of the line), he leaves it and walks back to take over the work of his predecessor, who walks back and so on, until the first worker walks back to start a new product.
WHICH COMPANIES ARE USING BUCKET BRIGADE?

- Subway
- McGraw Hill
- Ford
- Time Warner
- Trade Publishing
- Mitsubishi Electric
- Gap
- Champion
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FILE WITH ORDER SHEETS

CUSTOMER ORDER #1

<table>
<thead>
<tr>
<th>Line</th>
<th>Location</th>
<th>Quantity</th>
<th>Picked?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>1</td>
<td>□</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>1</td>
<td>□</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
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<td>9</td>
<td>14</td>
<td>2</td>
<td>□</td>
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