

## **School-company Relationship as A Means of Application of Methods Engineering and System Simulation**

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**Abstract:** Nowadays, the School-Company relationship offers students the opportunity to apply the knowledge they acquire during their professional development. This research shows how, based on the need to increase production and improve the current operating conditions of a company in the glass industry, a team of young people who are studying for industrial engineering were allowed to have access to the company to carry out projects focused on method engineering and simulation, with the aim of developing practical experience in process improvement. For the development of the project, tools were used for engineering methods such as data collection, direct observation, time study with stopwatch, time analysis, movement study, process documentation and operation simulation using PROModel Simulator software, resulting in the solution to problems related to delays, waste, materials, ergonomics and industrial safety. In addition to the previous ones, the greatest learning of the students was to verify the veracity of the information collected through the engineering of methods and measure the impact of their improvements in a simulation, generating a 43% increase in production capacity.

*Keywords:* School-company Linkage, Methods Engineering, System Simulation

### **1. Introduction**

Nowadays, the School-Company relationship continues to be relevant both for the student, who acquires experience outside the classroom, and for the school that promotes the quality of the knowledge provided in their institution, as well as for the company that takes advantage of fresh minds that help detect areas of opportunity unnoticed by workshop blindness.

According to Grajeda et al. (2019), the School-Company linkage constitutes an excellent education space for undergraduate students, where when they carry out their social service or professional practices, they contribute to both their professional and academic training, by offering a learning environment that allows them to practice what they have acquired in class, in addition to boosting the skills they require when they graduate. Alcantar et al. (2017) presents linkage as the ability to support positioning the university in the face of the company's perception of the institution, so that linking can be an effective tool when promoting the institution as a relevant means.

This research project shows how a group of young students had access to a company to carry out projects focused on method engineering and operations simulation, with the aim of developing practical experience in process improvement.

#### **1.1 Context**

The present investigation was carried out in a manufacturing company, with ten years of experience in the glass industry, located in the metropolitan area of the state of Nuevo León. The company focuses its products on the commercial and residential market, however it has begun to have difficulties on satisfying the demand for the “double glass” product of its main customers.

#### **1.2 The Purpose of the study**

When this problem appears in the company, a group of students of industrial engineering of the Faculty of Chemical Sciences saw as an area of opportunity the situation to offer an effective solution and improve the production of double glazing. Double glazing is a double glass system that allows energy savings and acoustic comfort. It consists in the union of two crystals

separated by a hermetically sealed air chamber, which can have argon gas to improve thermal properties. These insulating glass units allow you to save energy, have solar control, improve acoustics and safety, achieving maximum comfort at the same time (Vitromart 2019). (Figure 1.)

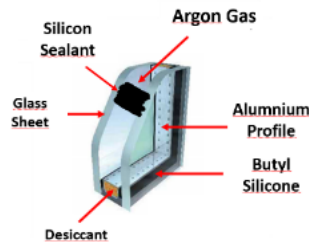


Figure 1. Double Glass (Vitromart 2019)

When students began planning an improvement proposal, they realized that the company did not have any work standardization, so there was no prior documentation of the process that would help to find problems or opportunity areas. This led them to a problem statement, find the limitations, and then raise the problem and find solutions.

## 2. Problem Definition and Methodology

The problem found was that it was difficult for the company to fulfill the delivery times, due to delay in receiving the product in process between the work stations, and rework produced by the lack of order, cleanliness, and industrial safety. Therefore, the limitations were the lack of manuals describing the processes carried out by the company, non-updated information about the control of production, there was no record of the standard times and efficiency of the personnel working in it.

Once the panorama was contemplated, the problem formulated was to find the possibility of improving production through engineering tools, so it was necessary to find the techniques and tools that allowed the optimization of the production process and how to apply them. For this, it was essential to establish a diagnosis of the production process with the help of the tools of method engineering. Starting from the formulated problem (hypothesis), selecting the indicators as independent and dependent variables, as well as the engineering tools (items) that allowed us to quantify the variables. (Figure 2.)

HYPOTHESIS	VARIABLES	INDICATORS	ITEMS
Develop a structured method to improve the production process	Variable Independent	Efficiency Effectiveness Time Utilization	Methods study scheme Operations Process Diagram Flow Process Diagram Stroke diagram
	Variable Dependent	% Efficiency % Effectiveness % Times % Use	Improvement of: Operations Process Diagram Flow Process Diagram Stroke diagram

Figure 2. Diagnostic table of the production process

The study of methods was carried out six of the eight phases. (Figure 3.)

**Phase 1:** Select the process to study.

**Phase 2:** Record the relevant data about the process by answering the questions, how does the process work? how long does it take?

**Phase 3:** Examine the data collected with the help of mathematical models to understand the process through indicators and a simulation was carried out with PROModel to compare the results.

**Phase 4:** Establish the possible solutions according to the previous analyzes.

**Phase 5:** Evaluate the proposals

**Phase 6:** Define the establishment of a new work model, a new simulation was developed to demonstrate the impact of the improvements.

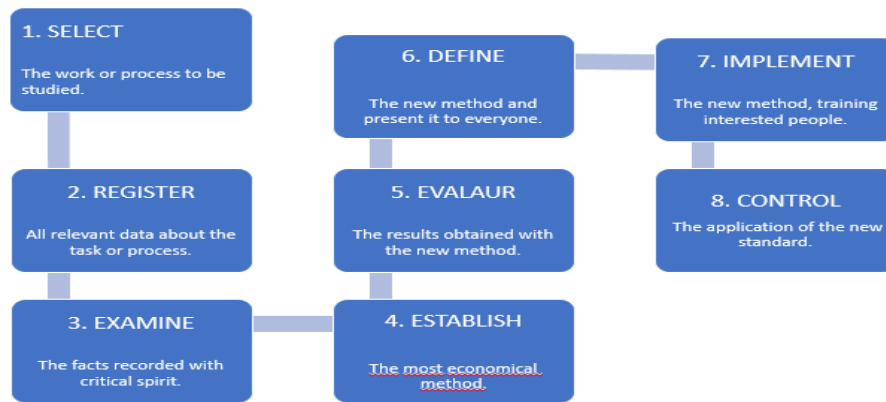


Figure 3. Scheme of study of methods

### 3. Analysis & Results

#### 3.1 Phase 1

Select the process to study, in this case the production line of double glazing.

#### 3.2 Phase 2

Record relevant data about the process

It consisted in the analysis and recording of activities. Direct observation, interviews with operators and production manager were important to know the processes and areas of opportunity in them. While time-taking was indispensable for establishing standardized times, as well as designing the operations diagram and the product flow chart.

In this phase the causes of the delays were found, they occurred due to the lack of order in the follow-up of the orders, the rework caused by the incorrect interpretation of the drawings, as well as the incidents and ergonomic risks for not using the transport cars, not even the right personal protective equipment.

In the operation diagram it was found that the bottleneck is the tempered glass with a standard time of twenty-four minutes, while in the process activity diagram a critical delay of one thousand eighty minutes was found consisting of the drying of Silicone that seals double glazing so that capacity and efficiency are affected.

Why is glass drying not the bottleneck? According to Heizer, a bottleneck is an operation that limits the output in the production section because it has less capacity than the work center while a delay occurs when the operations do not allow an immediate activity. Next or that activity is not required. Except when these circumstances intentionally change the physical / chemical characteristics of the object whose case is considered to be no delay but an operation (Heizer and Render 2004, P.620). Wait, delay: when conditions do not allow the execution of the next planned activity, we say there is a delay. (Figure 4.)

	<u>Activity</u>	<u>Time (min)</u>	<u>Distance</u>
○	<u>Operation</u>	35.34	0
⇒	<u>Transport</u>	28.92	81.1
D	<u>Delay</u>	1080	0
□	<u>Inspection</u>	0	0
▽	<u>Warehouse</u>	0	0
◻	<u>Combined</u>	53.50	0

Figure 4. Summary of flowchart of the study of methods

### 3.3 Phase 3

Examine the data collected with the help of mathematical models to understand the process through indicators.

According to the operators of the double glass line, the ideal is to prepare fifteen double glasses per day and approximately only 12 are completed. The work schedule is from 8 am to 6 pm with a meal time. Both data are relevant to be substituted in mathematical models for the analysis of production. With the data collected, the third phase began.

Analysis:

$$\begin{aligned} \text{Current capacity} &= \text{Available time} \div \text{Bottleneck} \\ \text{Current capacity} &= 540 \text{ min} \div 24.216 \text{ min} \\ \text{Current capacity} &= 22.29 \text{ pieces / day} \end{aligned}$$

A simulation was carried out respecting the logic of the process, using the standardized activities and times of the process and flow diagrams. Why the real logic of the process? When the operators finish applying the silicone and let it dry they do not wait for the process to end, they return to the first station of the double glass assembly to prepare another and continue on until the end of the day, in order to take advantage of the first hours the next day to finish them. This is not contemplated by any mathematical model, so with the information collected it was necessary to make a simulation with ProModel to obtain a more detailed analysis. (Figure 5).

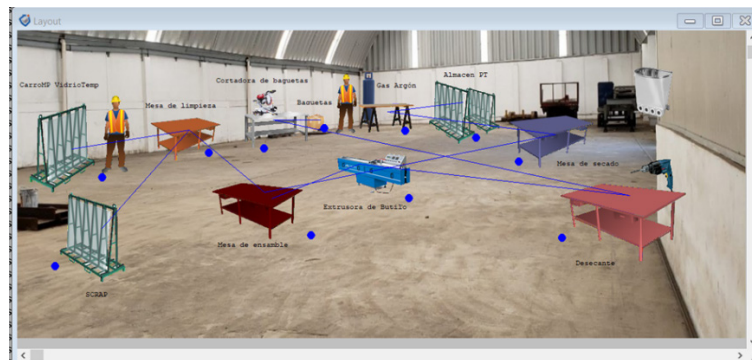


Figure 5. Simulation in ProModel

According to the simulation in the week 63 double glasses were produced (Figure 6.), if we compare the daily production proposed by the operators of fifteen double glasses per day, with which the simulation throws respecting the logic of the process, we find a demand daily of 10 double glasses per day.

Nombre	Total Salidas
Vidrio Templado	154.00
Bagueta	0.00
Bagueta CD	0.00
Bagueta CDB	308.00
Ensamble Duo	0.00
DuoPT	63.00
Duo con gas	0.00
Vidrio TMalo	26.00

Figure 6. Current weekly production in ProModel

The actual production is going to be considered as the one that gave us the simulation of 10.5 pieces per day. The design capacity is going to be that which resulted from the current capacity formula of 22.29 pieces per day. The effective capacity will be the design capacity contemplating 15% scrap in the simulation, with 18.94 pieces per day.

$$Use: \frac{(Actual\ production)}{(Design\ capacity)} * 100 \quad Use = \frac{10.5}{22.29} * 100 \quad Use = 47.10\%$$

$$Effective: \frac{(Actual\ production)}{(Effective\ capacity)} * 100 \quad Effective = \frac{10.5}{18.9465} * 100 \quad Effective = 55.4192\%$$

It was obtained that the use is 47% and an efficiency of 55.4% which showed us that the line is being unproductive, so that a production line is productive at least 70% must be exceeded.

It is important to add that with direct observation, activities were identified that put operators at risk in terms of safety and hygiene and ergonomics.

As for safety and hygiene, the operators were asked about the most frequent accidents per month, and this was what was found.

PROBLEMS RELATED TO SECURITY	Frequency (MONTH)	%
WOUNDED BY DRIVING CRYSTALS	15	50
MUSCLE CONTRACTS WHEN HANDLING GLASSES	8	26.6
CRYSTAL BREAKS	5	16.6
FALLS	2	6.6
TOTAL	30	

Figure 7. Security-related problems

An AMEF diagram was carried out to find the risk in the accidents that occur most frequently in the plant. The AMEF diagram showed a risk priority number (NPR) greater than 100 for each of the situations, which represents a clear indicator that prevention or correction actions must be implemented to avoid the occurrence of failures, as a priority, this It is because an accident with a glass could have permanent or fatal repercussions on the operators.

On the other hand, a RULA (Rapid Upper Limb Assessment) analysis of several non-ergonomic positions was performed. From this analysis it was found that activities to prevent injuries have to be analyzed in greater detail. As mentioned earlier, these types of activities are critical in the health of operators.

### 3.4 Phase 4

Establish possible solutions according to previous analyzes (improvements).

Already with the results of the indicators, for the fourth phase two analyzes were carried out: 1) The seven questions and 2) The principles of analysis of the operation. Both led us to the fact that the aspect to improve in the process is the use of the raw material, in this case the change of the silicone for one of drying of less time. Move from silicone A with a drying of 14-18 hrs to one B with a drying time of 5 - 8 hrs. Drying reduction from 1080 min to 480 min. Increase in the arrival of raw

materials from 30 (what was set to make 15 glasses) to 50 tempered glasses (now to make 25). Reduction of the probability of scrap from 15% to 10%. Ergonomic aspects when transporting the pieces from station to station and order in the handling of work orders.

### 3.5 Phase 5

Evaluate the proposals (improvements)

1. With the change of the silicone one has a faster drying time so it will be possible to empty the drying area much faster allowing the occupation of the area to decrease and improve the process flow.
2. It is worth mentioning that there will be an economic benefit when using the new silicone, since the one currently used, Silicone A, has a cost of \$ 229.00, while the silicone that is proposed to use, Silicon B, has a cost \$ 174.00, saving \$ 55.00 for each silicone canister used.
3. With an appropriate cutting table for the baguetas the operators would not have problems measuring the baguetas in the air or having problems to cut them because the length does not fit in the table they currently have, in addition to that with a suitable table the measures of the baguetas would be correct avoiding measurement errors and waste by baguetas that are not to the required size of the glass.
4. Because it is a repetitive activity, the operator should not be subjected to unnecessary efforts, in addition to the use of unsuitable utensils, they usually throw away the desiccant by mistake producing waste that is reflected in the costs.
5. The mobile tables for drying would allow the height of the table to be adapted so that the operator does not submit to inappropriate postures and to avoid injuries.
6. Implement shelves for drying that instead of leaving them on a table where they barely fit and there is a risk of throwing them, the shelves would serve to give them a better place and that they do not hinder when they need to work with another double glass.

### 3.6 Phase 6

Defining the establishment of a new work model, a new simulation was developed to demonstrate the impact of the improvements.

$$\begin{aligned} \text{Proposed capacity} &= \text{Available time} \div \text{Bottleneck} \\ \text{Proposed capacity} &= 540 \text{ min} \div 26 \text{ min} \\ \text{Proposed capacity} &= 20.7692 \text{ pieces / day} \end{aligned}$$

The actual production is going to be contemplated as the one that gave us the simulation of 15 daily pieces.

The design capacity will be that which resulted from the current capacity formula of 20,7692 pieces per day.

The effective capacity will be the design capacity contemplating 10% scrap in the simulation, with 18.94 pieces per day.

$$\text{Use: } \frac{(\text{Actual production})}{(\text{Design capacity})} * 100 \qquad \text{Use} = \frac{15}{20.7692} * 100 \qquad \text{Use} = 72.22\%$$

$$\text{Effective: } \frac{(\text{Actual production})}{(\text{Effective capacity})} * 100 \qquad \text{Effective} = \frac{15}{18.69} * 100 \qquad \text{Effective} = 80.247\%$$

They went from producing 63 weekly pieces to 90 per week, so we found a 42.85% increase in production capacity. A 25% increase in the use of the production system and efficiency (Figure 8).

Nombre	Total Salidas
Vidrio Templado	154.00
Bagueta	0.00
Bagueta CD	0.00
Bagueta CDB	308.00
Ensamble Duo	0.00
DuoPT	63.00
Duo con gas	0.00
Vidrio TMalo	26.00

Nombre	Total Salidas
Vidrio Templado	234.00
Bagueta	0.00
Bagueta CD	0.00
Bagueta CDB	468.00
Ensamble Duo	0.00
DuoPT	90.00
Duo con gas	0.00
Vidrio TMalo	25.00

Figure 8. Comparison of current and proposed weekly production in ProModel

#### 4. Conclusions

Through the School-Company relationship, this group of young people had the opportunity to apply the tools seen in class focused on method engineering and operations simulation; the practical experience, which they acquired in each phase carried out, gave them the security of comparing and verifying that the timing was correct since these data were entered in the ProModel simulator and at the end of the shift the amount of simulated production was the same as the real; A simulation was also developed with the proposed improvements to demonstrate the benefits, especially in increasing production by 43%.

The key to the success of this project was thanks to the full access of the company's information, so that a good school-company relationship must guarantee openness for students so that projects like these can transcend and be effective within the facilities.

Although the project only included the completion of phase 6 of the method study scheme, the company considered implementing (phase 7) the proposals to improve silicone change and safety and hygiene within the plant, as well as the documentation of the processes and its standardization with the data collected and presented to the company, its CEO made the decision to acquire an automated machine that includes cleaning, assembly and drying processes with an approximate cost of 180,000 euros.

As a proposal for future research it is convenient to conduct a study with the new machine acquired.

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