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New ways to evaluate learning. Assessing teamwork using TPM and a Poka-Yoke design

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Abstract

In this paper we present a hands-on experiment for measuring learning through teamwork applied to solving a real problem.

The experiment is part of the Production Systems course and involves designing a Poka-Yoke, but not theoretically, as is usually the case, rather an actual working mechanism. To this end, a practical problem is proposed for which a physical machine has to be designed to solve the problem. As part of the same exercise, a TPM is developed, also applied to a real case, such as assembling a bicycle.

In the case of the Poka-Yoke, two simultaneous objectives are pursued: to avoid a defective product, and to maximize the production per unit time. The final score is assigned based on a measurement of these two parameters.

Once the exercise is assigned, the teamwork is verified to be measured efficiently, even when the number of students is high. The physical design of the elements, as well as the simultaneous engagement by all the students in the exercise, served to considerably raise the motivation of the students.

Keywords: *Cross-disciplinary skills, Poka-Yoke, T.P.M., production system.*

1. Introduction

Effective teamwork and problem-solving skills are becoming increasingly important. Implementing and measuring these skills is difficult, requiring new tools in order to be used efficiently.

Some authors, like Bowden and Marton (2012), have already shown the need to use project- or problem-based learning, while others, like Antoni and Laia (2008), have gone further, stating that being skilled means being able to respond efficiently to a real situation. It thus seems obvious that the starting point for any evaluation should involve a more or less real situation that somehow captures what one can find in the real world.

Teamwork is also essential to solving these real problems. Even in some highly complex problems, teamwork is more important than individual skills, as detailed by Villardón-Gallego (2015). According to Brown and Pickford (2013), these skills should be evaluated live so as to effect a better and more realistic assessment.

Considering all of these requirements – solving real problems using teamwork and live tests – we present an exercise performed as part of a Production Systems course that offers good results at a minimal cost.

2. Skills to evaluate

During their 6th semester, Industrial Electronics and Automation Engineering majors at the University of Burgos take a required course on Production and Manufacturing Systems.

The skills defined for this course and evaluated through the exercise detailed below are:

- Analysis and synthesis

- Effective problem solving

- Teamwork

The large number of students taking this course drove us to design this exercise so that we could evaluate these skills using a real scenario.

3. Production Systems

Before explaining the experiment, we will describe the subject and context on which it is based. Within the Just-In-Time production system there is a quality tool called the JIDOKA, as explained by Yasuhiro (1987).

Jidoka is a Japanese word that in the lean manufacturing methodology means "automation with a human touch". Jidoka allows for a process to have its own quality control.

Within Jidoka is the Poka-Yoke tool, a technique for correcting and detecting production defects that relies on mechanisms to warn of an operational fault or of a defective product. It can even stop the production line or machine if necessary.

Poka-yokes usually involve:

1 – A detection system, whose type will depend on the feature to be monitored and based on which they are usually classified, and
2 – An alarm system (typically visual and audible) to notify the worker of the error so it can be corrected.

The phases for implementing a poka-yoke are:

1 – Understanding how a process is failing.
2 – Deciding the correct poka-yoke approach (eliminating unnecessary elements and adding new ones).
3 – Determining if the handling, number of actions and sequence are appropriate.
4 – Using the method and checking its operation.
5 – Training workers on the measure adopted.

Total Production Management can be defined as a system through which every worker takes part in preventing, detecting and correcting faults in designs or in the operation of machinery. According to Samuel and Christopher (1994), it is a method for avoiding wastage that relies on every worker to improve processes.

4. Exercises proposed

The TPM exercise consists of assembling and disassembling a bicycle, making the associated materials, measuring parameters, etc.

The Poka-Yoke exercise proposed consists of solving the following problem:

- At a work center, four holes must be punched into sheets measuring 297x210 millimeters. On one side of the sheets is a mark indicating whether the sheet is type 1 or type 2. The mark has a 1-mm diameter.

- On type-1 sheets, the mark is 107 mm – 149 mm away from the origin (bottom left corner), and the punch holes go to the left. On type-2 sheets, the mark is 107 mm – 146 mm away from the origin, and the punch holes go to the right.

The sheet is handled vertically, as is the hole punch. All the sheets have the same dimensions.

A poka-yoke has to be designed to improve the work station so as to maximize production while ensuring that the holes cannot be punched on the wrong side. The sheets arrive in random order.

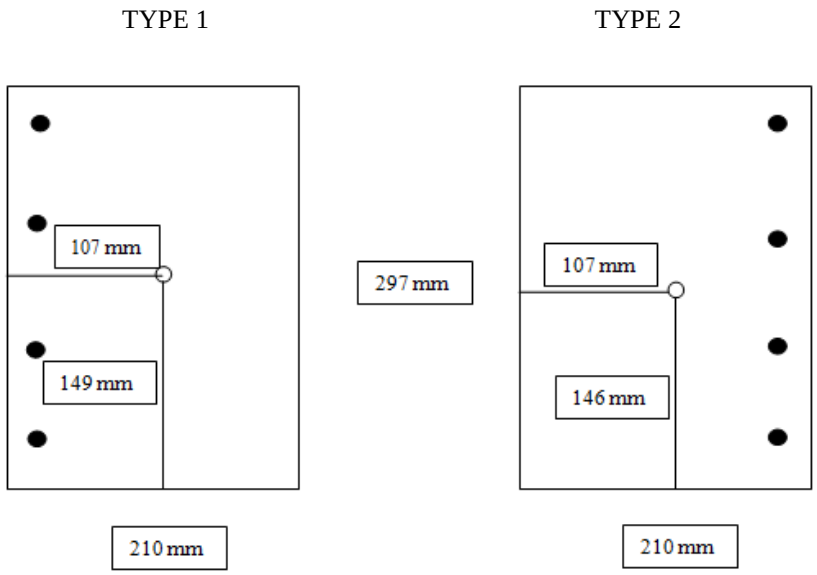

Figure 1. Problem proposed.

This is not a theoretical proposal; rather, physical components have to be developed to detect the type of sheet involved so the holes are made on the correct side. The system has to be effective. The work is carried out in groups of four students each.

The groups will be evaluated by giving each one a set of parts (sheets) that has a mixture of type-1 and type-2 parts. The part type has to be identified and the holes punched on the correct side. The two objectives are correct identification and speed, which are assessed by counting the number of sheets punched incorrectly and the time employed. The exercise is graded using the following criteria:

- The test involves 20 sheets total of both types, and can be assigned a maximum of 1.5 points.
- Two or more faults will result in everyone on the team being given a 0.
- The score with 1 fault will be 0.5 points.
- With no faults, the time used is considered for all the groups that had zero faults and a grade of 0.5 to 1.5 points is distributed proportionately.

In other words, zero faults and the worst time receives 0.5 points, zero faults and the best time is 1.5 points and the rest are graded proportionately between these extremes.

Another important condition is that the person doing the test is chosen at random from the group just before the test, thus ensuring that every group member took part in the design and practiced using it.

The four groups were given a hole punch that they could take home to use in their design and to practice with. Since four identical hole punches are available, four groups are tested at one time (see Figure 2). The test is not repeated.

Figure 2. Hole punches used.

5. Results of the exercise

This experiment was carried out as part of the Production and Manufacturing Systems course for Industrial Electronics and Automation Engineering majors (48 students).

The students were arranged into twelve groups of four.

In the TPM case, the results were very satisfactory, since the groups performed the physical assembly, made the corresponding materials and acquired all of the group skills proposed.

Figure 3 shows some of the materials made by one group, such as a graphic diagram with operations to be performed to remove the bike

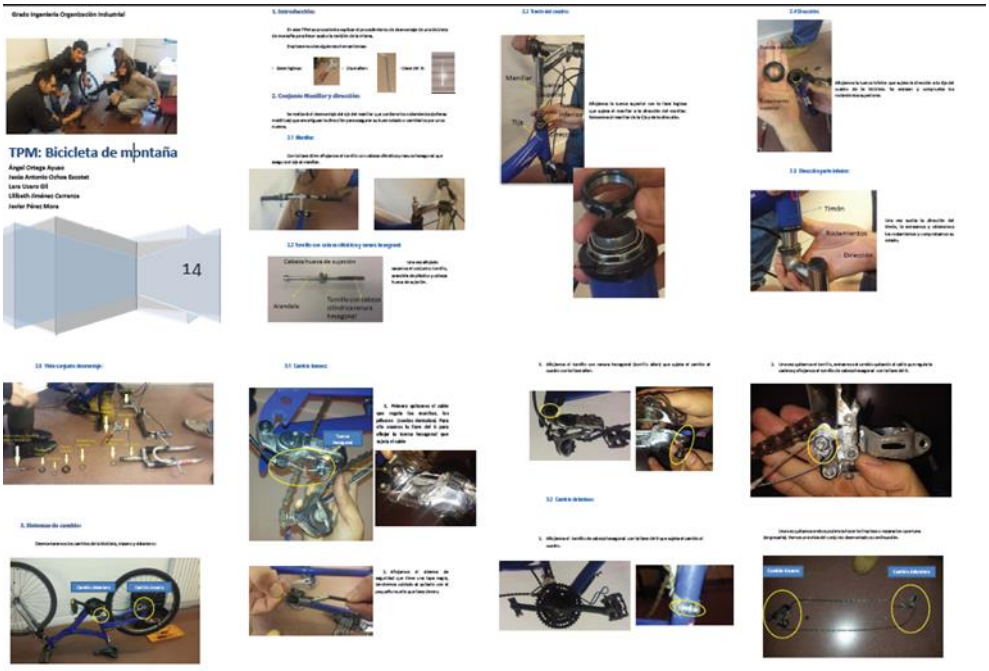

Figure 3. Sample of materials made during the TPM.

For the Poka-Yoke exercise, the number of faults, time used and final score are shown in Table 1.

Table 1. Results of the exercise.

FAULTS	2	1	0	0	0	0	0	0	0	0	0	0
TIME	-	-	6.40	5.50	4.56	4.16	3.33	3.23	3.10	2.41	2.2	1.51
SCORE	0	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5

The exercise was useful for evaluating the skills proposed (analysis, teamwork and effective problem solving). In this exercise, all students in the same group have the same note. Students had two months to prepare these two exercises

It was well received by the students and having the score depend on the relative times fostered competition.

The financial cost of this exercise is minimal. These exercises can be performed in smaller classes (e.g. 12 or 16 students), but also by smaller groups.

Different courses can use new exercises with small variations. For the TPM exercise the same methodology can be applied to the assembly and disassembly of a computer, and for the Poka-Yoke exercise, the symmetry of the exercise can be altered, as this would entail designing new physical elements. Figure 4 shows one variant in which the mark also exhibits a 3-mm symmetry about the diagonal.

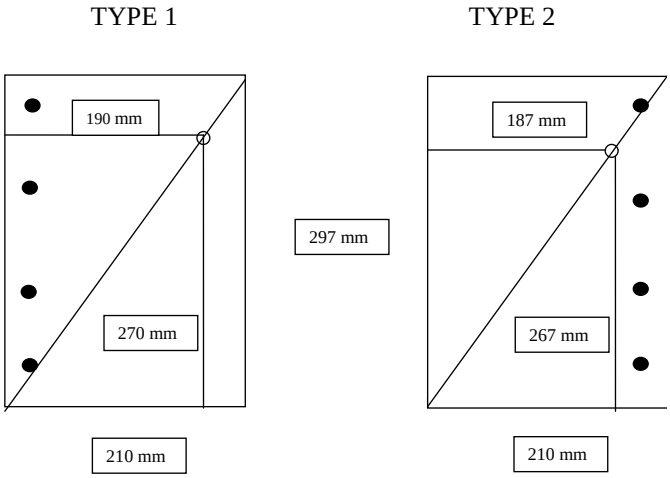

Figure 4. Variant of problem statement.

The Poka-Yoke exercise can be improved as follows:

- By using very high quality sheets. Since the marks are only 3 mm apart, a poor quality photocopy can lead to mistakes. (This was detected after performing the exercise).
- Given more time, and so as to improve the learning process, a follow-up test can be given since some of the groups did not anticipate potential problems, leading to low grades on the exercise.

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