USING SIMPLE EXPERIENTIAL LEARNING ACTIVITIES
ENCOURAGE LEARNING OF OPERATIONS MANAGEMENT
CONCEPTS

Angel Peiro-Signes¹, Oscar Trull-Dominguez², Maria del Val Segarra-Oña¹,
Blanca de Miguel-Molina¹

¹ Departamento de Organización de Empresas, Universitat Politècnica de València (SPAIN)
² Departamento de Estadística e Investigación Operativa, Universitat Politècnica de València
(SPAIN)

Abstract
This paper focuses on developing an Experiential Learning Activity (ELA) to transmit the basic
concepts about control charts. ELAs are a powerful tool developing meaningful learning of several
concepts, working with transversal competences and maintain the students interest and motivation on
the subject. This paper tries to show how instructors can develop simple experiences to make a real
change in the way they teach so they can adapt to the new requirements of the educational
environment. Learning objectives in a regular session in the area have to do with the ability to apply
and analyse control charts: preparing and using control charts to a process, determine out-of control
situations or differentiating common from special sources of variability. We demonstrate how we can
use a simple kid's toy to help students to learn about these operations management concepts,
developing a motivating session which will end up in meaningful learning. Results on the outcome of
the activity are encouraging, students where able to relate aspects in subsequent sessions to the
situations and knowledge acquired through the activity. Furthermore, students were able to recall after
a while the basic principles and concepts experienced during the activity.

Keywords: Experiential Learning Activities, operations management, control charts.

1 INTRODUCTION
Stephen Elop, Nokia’s CEO, wrote a famous e-mail to Nokia employees about a burning platform. He
introduced a story about a man who was working on an oil platform in the North Sea and suddenly
woke up and the entire oil platform was on fire. The man standing on the platform's edge had to make
a choice between been consumed by the fire or plunging into icy waters. He intended to encourage
change on an organization making employees realize that they cannot follow the same path as in the
past. He encouraged the organization to adapt to the new environment, to do things differently.

There are some points in a teacher’s life when we face ourselves within similar choices as the one
described by the story. Time is scarce, contents and competences to develop are too wide, keeping
students interested in the matter gets harder and harder and teaching methods and technology evolve
very fast.

In this context, instructors have either maintain themselves doing the same things than the previous
years or jump in to the “freezing waters”. Freezing waters represent a change, a shift the instructor’s
behaviour, to “take a bold and brave step into an uncertain future” by changing how instruction is
delivered. New methodologies, new activities, different focus, etc. Change to adapt to the new
educational environment is necessary.

We strongly believe that activity in the class should be of the student interest. To light the interest on
the students we have multiple choices and each methodology has some key elements to do it.

In our experience, Experiential Learning Activities (ELAs) are a powerful tool developing meaningful
learning of several concepts, working with transversal competences and maintain the students interest
and motivation on the subject [2]. This paper tries to show how instructors can develop simple
experiences to make a real change in the way they teach so they can adapt to the new requirements
of the educational environment.
2 OBJECTIVES

Changing regular classes to introduce ELA’s is a big change for instructors. There is a big shift on the teacher’s approach to the class, many times it requires the instructor to develop new skills and competences, and the planning phase emerges as crucial in the process.

This paper describes how to develop an Experiential Learning Activity (ELA) to show students how to build, use and analyse Control Charts. Based on a child’s toy we have develop an experience to change the way Control Charts are taught to achieve a meaningful learning and to increase the student motivation in the class activity.

To plan an ELA we have to consider many aspects such as, the concepts to be delivered, the skills and abilities the students have and the ones we want to develop, among others [3]. Additionally, we have to keep in mind infrastructural constrains such us, the size of the classroom, the number of students or the resources and time available for instruction. The key element in planning an ELA is to clarify the purpose of the experience. The learning objectives must be clear from the very beginning so all the activity can be developed to build on them.

LaForge and Busing [4] indicated a process to develop ELA’s from the planning to debriefing going through the phases introduction and execution of the activity. In this paper, we develop the ELA phases to illustrate a fundamental technique of quality control.

3 METHODOLOGY

3.1 Planning

Planning is vital to the development of the ELA. Is a key phase in the activity success. It starts outlining the objectives and continues with the development of the bases of the experiences. It finishes indicating how to manage the experience and how conduct the debriefing.

As indicated by Halpern and Hakelh [5] the major complication from the instructor’s point of view has to do with the design of the experience. An experience that, without the complexity of the productive reality, is able to reflect in a relevant way the important aspects of what we want to teach. The experience should require students to make decisions and some reflection at the end of the process in those situations that came up during the activity [6], [7]. Is precisely in this phase, through critical reflection of the activity process and connection to previous learnings, when students reach a meaningful learning.

Quality has been an important topic for companies through the past decades. The quality management techniques and methodologies were designed and developed to retrieve data from a process, display or monitor the data or prioritize decisions.

Control Charts have been used for years as a graphical display to monitor processes over time. Typical applications of control charts have been related to monitoring processes to detect and correct problems as they occur, determine the stability or the patterns of the process, to determine the expected outcome of a process or to evaluate the result of a quality improvement in the process.

Processes surveillance requires to be able to differentiate normal from abnormal situations. In this line, control charts differentiate between in-control and out-of-control processes. In other words, to differentiate between common causes and uncommon causes of variability.

Applying control charts can be divided in two steps. The first step uses historical data to determine the control lines. Control lines are defined by the central line and the upper and lower control limits. The central line is calculated based on the average indicators, while the limits are determined based on historical variability (standard deviation, range,…). In the second step, we compare current data to these lines. Data are plotted to show variation of the indicators over time. This comparison will allow the practitioner to draw conclusions about the predictability of the process. If the process variation is consistent, process is under control. On the contrary, if it is unpredictable, special causes are affecting the process and, therefore, the process is out-of-control.

Control charts for variables are structured in pairs, covering the centering of the data distribution of the process and the variability of the distribution.

This paper focuses on developing an Experiential Learning Activity to transmit the basic concepts about Control Charts. Learning objectives in a regular session in this area have to do with the ability to
apply and analyse control charts: preparing and using control charts in a process, determine out-of-control situations or differentiating common from special sources of variability.

The experience have been designed over a child’s game. The game is quite basic. Several cars are moving through a track by action of gravity. Two belt elevators, take the cars from the lower areas of the track to the higher areas to keep the cars moving down again. The game has three coloured cars. These cars because they are not exactly equal and neither the paths followed in the track have slightly different lap times. Eventually, each car completes the track, on average, in a different lap time.

Moreover, as mentioned before, as cars do not follow exactly the same path each lap or elevator do not run exactly at the same speed each lap, between other causes, is giving us a source of common variability for each car.

Thus, each car turning laps in the track represents a process. The aim of the experience is to control the process as a mean to achieve the aforementioned objectives related to control charts.

For the experience we will need several resources besides the toy. We will touch on each of them as they are needed.

3.2 Introduction

Materials should be prepared by the instructor before students come into the classroom. The game involves breaking the group up into four teams of three to four students assigned to each car. They are all told that they will be involved in controlling a process. The groups are then allocated different roles.

3.3 Activity

First objective is to construct the control chart. We will need a data sheet. This data sheet will allow the students of each team to capture the data needed to determine the central line and the upper and lower control limits. In this case, we used an average-range Control C chart. We used double graph control charts as special causes might cause to shift either mean or variance or both at the same time Gan et al. [8]. Thus, combining the information of two parameters on one sheet might monitor the process more accurately.

Students will also need a stopwatch or cell phone to monitor the lap time. Two members of each group will start taking measures of the time lap in series of 5 laps. Initially students will allow cars to run for four to six laps till time laps are stable and no problems are detected. Picking the top of one elevator belt as the initial point, students will make 25 series of 5 measures, leaving 3 to 4 laps between series. Results will be recorded meanwhile by the other members of the group in an excel spread sheet.

Once “historical” data is retrieved, students will be instructed on calculating the central line and the upper and lower control limits, following the formulas indicated on the data sheet.

Second objective is to learn to use the control chart. In this step of the experience, student will take samples at specified sampling intervals and will plot values on average and range on a graphical sheet that now includes the control limits previously calculated. Control limits are decision lines, which in the first simpler analysis will allow students to discriminate in-control from out-of-control. For this part, student roles are changed, so each one has been able to experience the different roles within the team.
After a few measurement rounds, students will realise that values of average and range plotted are between the limits. The process is stable, operating within the desired limits. The process is running under the influence of common causes of variability and no countermeasures should be taken.

Now is time to introduce special causes of variation. The game is prepared to introduce several causes of variation which might result on different typical out of control signs.

First out of control is deliberately caused by the instructor under the students’ watch. The instructor slows down the belts putting the finger on the belt while at least one of the cars is being elevated. This will cause one or two cars to increase the lap time significantly. When students plot the result of the series the mean point will be out of the upper limit, indicating an abnormal behaviour of the process. This might encourage some discussion about the causes of the variation that should introduce the students to the next part of the experience.

To simulate special causes we incorporated an external direct current (DC) power supply device. The original game runs with a pack of 2 AA 1.5V batteries (3V power supply). However, DC motor in the toy is able to run at a higher and lower voltage. We use a 12 V power supply with a rheostat to control for the voltage supplied to the toy, ranging from 2 to 5V. An increase on the voltage will increase the speed of the engine and vice versa. Increasing the speed of the power supply will speed up the process and eventually create a result on a point out of the control limits. We prepared a set of

Figure 2. Sample outcomes of student’s results in the experience.
experiences to uncover possible out of control measures so students can experiment them. Table 1 shows the set up and the expected result on the control chart.

<table>
<thead>
<tr>
<th>Experience</th>
<th>Out of control sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase voltage to 5V. Make one series of 1 or 2 measures.</td>
<td>A single point outside the control limits (upper control limit).</td>
</tr>
<tr>
<td>increase voltage to 3.5 V. Make 12 series of 5 measures.</td>
<td>Seven or more consecutive points on the same side of the centreline.</td>
</tr>
<tr>
<td>Increase voltage from 3 to 4.5 V in 0.25 V steps. Make 1 or 2 series of 5 measures in each step.</td>
<td>Six points in a row steadily increasing or decreasing</td>
</tr>
<tr>
<td>Increase the voltage to 4V, then measure, change it to 2V and measure. Repeat the process several times.</td>
<td>Points alternating up and down (overcontrol)</td>
</tr>
<tr>
<td>Increase the voltage to 4V. Make 5 or 6 series of measures.</td>
<td>Two out of 3 points in the outer third of the control region.</td>
</tr>
</tbody>
</table>

3.4 Debriefing

Students will spend between 40 minutes to 50 minutes to develop all these experiences.

Once completed the students will discuss for 15-20 minutes the patterns that follow each experience, possible reasons of the variation in a real world process.

Debriefing starts after group discussion. The instructor will summarize the experience focussing initially on which are the causes of common variability in the game. Students should come up with answers such as: the cars are not exactly the same (they have different shapes, car wheels and axis have not the same friction, etc.), cars do not follow exactly the same path (curves are taken differently, the belts grab the car differently each time, etc.), the belt can have different speed (microvariations on the speed of the belt), the time controller is not stopping the stopwatch at the exact same point each lap, etc.

After the first part of the discussion, common causes should be clear and the instructor might want to discuss the special causes and how they affect the mean and range values in the graph. The purpose is to let the student realize that when the process is under common variability all the plots will be in between the limits and normally distributed around the central line, while out-of-control situations will end up in points out of the limit or patterns that are uncovering abnormal behaviour. The instructor might want to use real situations related to the degree the students are taking. For example, in mechanical engineering, we might want to use the diameter of a shaft as an example to show up situations that might happen when the mechanizing process is not under control, such as, tool wear or over control of the process.

4 RESULTS

The success of the failure of the activity should be evaluated in the terms of the results. We evaluated results after the introduction of the experimental activity on the basis of student’s perceptions. We used a questionnaire with a Likert 1 to 5 scale, where 1 corresponds totally to disagree and 5 to totally agree.

Table 2 shows the result of the evaluation questionnaire of the activity carried out on the first two experiences and a total of 32 students.
Table 2. Questionnaire and evaluation results of the activity.

<table>
<thead>
<tr>
<th>Questions</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did the activity helped the team to learn how to take the data needed to</td>
<td>4,86</td>
</tr>
<tr>
<td>build the Control Charts?</td>
<td></td>
</tr>
<tr>
<td>Did the activity helped the team to learn how control limits are calculated?</td>
<td>4,21</td>
</tr>
<tr>
<td>Did the activity helped the team to learn how a process is monitored</td>
<td>4,64</td>
</tr>
<tr>
<td>through Control Charts?</td>
<td></td>
</tr>
<tr>
<td>Did the activity helped the team to detect when a process is under control</td>
<td>4,57</td>
</tr>
<tr>
<td>using Control Charts?</td>
<td></td>
</tr>
<tr>
<td>Did the activity helped the team to detect when a process is out-of-control</td>
<td>4,07</td>
</tr>
<tr>
<td>using Control Charts?</td>
<td></td>
</tr>
<tr>
<td>Did the activity helped the team to determine possible causes of a process</td>
<td>3,79</td>
</tr>
<tr>
<td>being out of control?</td>
<td></td>
</tr>
<tr>
<td>Did the activity helped the team to differentiate between common variability and variability due to special causes?</td>
<td>4,50</td>
</tr>
<tr>
<td>To which extent do you think that you could carry out the control of a process by yourself from what has been learned in the experience?</td>
<td>3,93</td>
</tr>
<tr>
<td>To which extent has the experience been preferable and motivating over a master class</td>
<td>4,79</td>
</tr>
<tr>
<td>Do you think the activity helped the group to act as a team?</td>
<td>4,71</td>
</tr>
<tr>
<td>To which extent has communication been important in solving the activity?</td>
<td>4,14</td>
</tr>
<tr>
<td>To which extent have you been able to participate and express your opinions in the group discussion and in the general discussion?</td>
<td>4,07</td>
</tr>
<tr>
<td>Would you recommend the experience to learn about Control Chart topics?</td>
<td>4,86</td>
</tr>
</tbody>
</table>

The results highlight the power of experience to motivate and acquire essential skills and concepts. However, complex concepts received the lowest scores from the students indicating that in depth discussion in this area will be needed to assure meaningful learning.

5 CONCLUSIONS

This article presents the development of an ELA designed to teach the concepts and skills needed in the use and analysis of Control Charts. The activity aims to help students in the learning process to obtain a more meaningful learning about quality control activities in the industrial and engineering area. We show how to use a simple children’s game to develop a motivating experience for the students. Based on the preliminary results, we suggest the instructor to put special emphasis on the more complex concepts and the analysis of the Control Charts in the debriefing phase as necessary reinforcement to reach meaningful learning through the experience.

The control of students’ perceptions through the questionnaire and the results through evaluation tests will serve the instructor to adjust the experience and achieve greater efficiency in the fulfilment of the experience objectives.

AKNOWLEDGEMENTS

This work is part of the study developed by the GAE (Experiential Learning Group) created as an EICE (Innovation and Quality Education Team) at the Politecnic University of Valencia (UPV). The authors would like to thank the UPV for the support through the PIME 2017 “Adaptation and development of experiential learning activities related to the subject context”.

REFERENCES


