Abstract: The authors describe a classroom experiment that demonstrates many topics which are related to process improvement. The students are assigned random numbers and asked to pass a ball, in number order, in the shortest time possible without dropping the ball. This pedagogical experiment illustrates a variety of concepts related to process improvement that are often difficult to teach without having a real life example. By actively taking part in the experiment, students gain a better understanding of process improvement concepts.

Keywords: classroom experiment; operations management; process improvement.


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1 Introduction

This paper describes a simple classroom experiment that provides students with a better and more comprehensive understanding of process improvement. A process is any part of an organisation that converts inputs into an output (implicitly of greater value than the inputs used). Organisations are continually looking to improve processes to create value to the firm in the form of increasing revenue, decreasing costs and managing risk. The concept of process improvement is discussed in most operations management and many management information systems courses, especially with topics such as new product development, lean production, theory of constraints, quality management, six sigma, inventory management, system design, to name a few (e.g. Cox and Goldratt, 1986; Harrington, 1991; Cua et al., 2001; Anand et al., 2010; Kamauff, 2010). Individually, each of these topics describes and puts emphasis on improving processes. However, students are often left without a practical sense of how to improve business processes. In fact, most business students will state the need to improve the process to improve efficiency or productivity, but do not know how to go about improving the process. The process for improving processes introduced by Kamauff (2010) is outlined in several steps. For example, first document the current process and identify problem areas. Next, determine possible causes and formulate possible solutions. Then, prioritise the possible solutions and decide on a plan with baselines and targets. After these steps, then develop a new or revised process and evaluate the changes. Repeat as necessary. When teaching operations management, the ‘how to’ of process improvement is complicated by factors such as the inherent use of team production and cross-functional activities commonly employed in manufacturing and service-oriented enterprises, which may escape students who lack real-world work experience. However, this is where a classroom experiment or demonstration can enrich the student learning environment in the area of information and operations management (e.g. Vragov and Wilson, 2005; Hilmola, 2006).

In our classroom experiment, students participate in the actual process and then attempt to improve the process in a systematic and analytical manner. In doing so, they realise the complexity and nature of the current process under consideration, but they also see how to improve the process thus adding value to the business at hand. Following different approaches to improving the process, students start to realise what is involved in improving even a simple process such as the one used in our experiment. We have found that by allowing students to be active participants in a ‘real world’ business environment, so that they gain a better appreciation and deeper understanding of what is involved in improving processes. Ideally, this enables the student to take these principles and apply them in other situations.

In this paper, we describe how the experiment can be conducted and modified to address a variety of concepts as well as how to handle other classroom constraints such as time or size. Unique features of this experiment are its simplicity and its flexibility. For example, the experiment can also demonstrate the effect of how teamwork can improve on a process. As such, the experiment can be used as a team-building exercise and illustrates basic management principles. In terms of flexibility, we describe the basic experiment along with several modifications to address a variety of classroom factors (i.e. lecture topics, class size, allotted time, etc.). We then provide a summary of the results of the different experiment variations that we have conducted in our operations management courses. Finally, we describe how the introduction and implementation of
process improvement can be demonstrated with this experiment. Future work could examine the experiment in some controlled manner to test for its learning outcomes and significance.

2 Basic structure of the experiment

A major benefit of this experiment is that it can be incorporated into a variety of courses (MIS, OM, etc.) and works well for a wide range of class sizes. Slight modifications of the experiment allow for its successful use within different time allotments. To start the experiment, each student should be randomly assigned a number. Each number essentially represents a distinct but interrelated function (activity or department) within the total process. There are many options to provide a random number to a student, in most of our cases the numbers were granted by order of birthdays. Following the assignment of numbers, the students are informed that they must pass a ball around to each person in numerical order. Each student must pass the ball (representing the input in the process) to the next person in proper order and the ball is not allowed to touch the ground (i.e. it cannot be dropped, bounced or rolled to another student during the process). This means that the students can toss the ball, hand the ball to the next person or otherwise transfer the ball by any means necessary without allowing the ball to hit or touch the ground. When the ball reaches the last student, the process is over (representing the output). In this experiment, the process improvement will be illustrated in how passing of the ball is refined to achieve the shortest time possible. The ball used in this exercise was the size of a tennis ball, but the experiment can be conducted using any small size (non-breakable) object. The instructor can impose some penalty for the ball touching the floor (i.e. dropping, rolling or bouncing the ball), but often the lost time from picking the ball up and continuing on with the process serves as a sufficient penalty.

3 Classroom demonstrations

3.1 Unstructured process improvement experiment

We have students seated in their normal places and ordered by their respective birthdays (within a calendar year). The students were told specifically that ‘the ball must pass through the hands of each person in the birthday order’. The ball is handed by the instructor to the first student, timer is set and students commenced passing the ball around the room. Often, the students want to try one more time, due to their delayed start or because someone has dropped the ball, and we recommend doing so to set the stage for marginal improvements by repetition. Most groups choose to call their number aloud to keep track of what number they are on. As the students get comfortable with the process of passing the ball around the room, we then challenge the students to improve on the process by some amount. Depending on your allotted class time, you can recommend a time goal that forces the students to change the process completely. Alternatively, you can recommend some time goal that is just out of reach for the group of students with passing the ball around (although they may try one more time). When you set a goal out of reach with the current process of passing the ball, you then encourage students to experiment with improving the existing process of passing the ball.
That is, the sequence selection is completely up to the students to derive and therefore allows them to communicate with one another to decide how they will execute the task. Here is an example from one of our classes.

As the first trial of the experiment took place, the group decided that a line would be the best choice to pass the ball in the fastest time possible (note that this choice may be discussed later and related to facility layout). As this first scenario played out, the ball was dropped and they all decided to try it again. The time for the first trial was 28.3 s. On the second trial, they chose to stay with the line layout and passed the ball without dropping it and improved their time to 20.5 s. The instructions then changed to cut the time by 50%. The students had a difficult time believing that they could arrive at such a goal and the leaders of the group started to reject ideas. After much discussion, someone commented that a circle would be a better idea to cut the time in half. The circle formation resulted in a significant decrease in time to 9.8 s. Another trial was performed to see if the students could beat the 9.8 s. This time, they decided to only pass the ball using their left hand and the time was further reduced to 8.4 s. Often, an important point at this stage of the experiment is that the group starts to use one method again leading to marginal improvements. Our experience indicates that this is where setting a goal that seems unattainable helps to motivate the students to improve the process further. This is a critical example of process improvement. The students in our class then turned to an idea of tilting the table (using gravity) while allowing the ball to pass through each student’s hand. In cases where you do not want to allow tables, desks or chairs to be used, the instructor can state that the ball may not touch a foreign object. In this demonstration, we only stated that the ball could not touch the floor. As such, the students’ first attempt was a failure, because the ball touched a backpack and resulted in a time of 18.5 s. Once they tried it again, their time went down to 5.5 s. The students repeated the process with some slight changes and their time was down to 5.1 s. At this point, the students were pleased with their improved process, but we have found that resetting the goal time can improve the process even further. For example, we asked if it was possible for them to get a time under 4 s. Most of the students started talking and were not sure that was possible, because they did not have any other ideas to alter the table strategy. After a few minutes, someone came up with the idea of a ‘totem pole’. This meant that they created a tube with their hands (in the appropriate order) and dropped the ball from above. This was in fact the best way to use gravity and reach the goal of ‘under 4 s’.

The experiment was a success in terms of reaching the various goals, and based on the student feedback, gaining a better understanding of process improvement. Overall, several themes emerged from this version of the experiment. Once the task was given, students first realised that they needed to listen to other ideas (note this can lead to a good discussion on idea formation and brainstorming). Second, the students learned to move on quickly from a process that was not working in their favour and experiment with new ideas. This is one advantage to running the unstructured process over the structured version discussed below. Finally, the students realised how process improvement could work in a decentralised manner as well as how students would formulate small groups to discuss an idea before presenting it to the class (especially if they were not ‘leaders’ and needed support to get their idea heard).

### 3.2 Structured process improvement experiment

This form of the experiment started with the same basic set-up as the unstructured version. The students were in their normal seats and ordered by their respective birthdays (within a calendar year). The students were then told specifically that ‘the ball must pass
through the hands of each person in the birthday order’. The ball is handed to the first student, timer is set and they passed the ball around the room. This was repeated several times for the students to get familiar with the process. The process times were presented to the class and displayed in some fashion (e.g. board, overhead or slide). At this point, the instructor puts the students into small groups. The groups are then tasked with examining the current process and addressing the steps to improve the process. In this more structured environment, the groups identify and discuss the problem areas of the current process. Doing so also allows the groups to address how and what their goals are to improving the process. For example, the groups may differ or disagree on whether the goal is to better the class time or minimise the risk of errors or ‘drops’. The groups are then asked to formulate possible solutions to improving the process. This is one key difference between the structured and unstructured version (i.e. the teamwork experiment), the latter of which consists of the entire class. For example, the unstructured experiment allows the class to experiment with different process designs to better the class time. The structured experiment requires the students to prioritise possible solutions and decide on a plan with baselines and targets. After these steps, the groups then develop a new or revised process and evaluate the changes. These steps are repeated as necessary. The groups are then asked to get up and present their new process to the class. While some groups may illustrate the same process, there is usually enough variation for the class to see different processes and have good discussion. The groups also realise how presenting their idea is an important step to getting the rest of the class to ‘buy in’ on the concept. That is, how they communicate their process improvement concept. While there is always concern with other groups sabotaging their classmates’ ideas, this has rarely happened. One reason for this is that the students need the other students to ‘buy in’ on their concept when it is their turn. This structured environment requires the groups to go through a vetting process of potential processes without any experimentation. Additionally, it is informative to ask the students when the structured environment might be preferred over an unstructured environment. Generally, students are quick to realise that the structured environment may work best when the costs associated with changing or altering the process are relatively high, as in the case of a firm having to purchase new equipment, etc.

4 Discussion and feedback

Both variations of the experiment illustrate a variety of concepts related to process improvement. For example, students often get stuck trying to practice (or repeat) the process to improve on time. This may be particularly true for students who are familiar with the notion of the learning curve. However, by looking for ways to change the process, the students experience substantial gains in performance. In fact, here is a comment from a student’s reflection paper:

Our class experiment was a great example of how a process can become ‘lean’. As the experiment was unfolding, I could see ‘lean’ characteristics coming out and it showed that ‘lean’ can improve productivity by a lot. It was very beneficial to actually witness and be a part of a ‘lean’ experiment and learn how to turn a situation into something productive.

This experiment, regardless of the design, provides class-generated data for the instructor to use to illustrate various performance metrics (e.g. capacity, throughput time, productivity, efficiency and cycle time). Along with the performance metrics, the difference between
the two experimental designs allows for additional topics to be covered. For example, in
the unstructured environment, class topics can include teamwork, communication skills,
decentralisation, leadership and negotiation, to name a few. In the more structured
environment, topics like communication skills are important (but used in a different
way), risk analysis, decision making and planning. For example, here are some other
comments from students:

First, effective communication between team members is essential. Everyone
talking at once is useless, and there was not a group effort to understand
everyone’s input.

The driving factors in the successful time were rooted in motivation and
teamwork.

I noticed as the challenges got harder, that it was necessary for more people to
shift from trying to be one of the leaders to being an active follower. In a group
of people all with leadership tendencies, it was interesting to see when people
would choose to take that step back and which ones continued to lead.

Interestingly, students often do not recognise the purpose of the experiment, especially
with the decentralised version, until it is almost finished as evidenced by this comment:

I participated in what seemed to be a rather off-topic class activity. In
hindsight, the class and I were participating in our own process improvement
experiment.

In addition, this experiment has also been used as an ice breaker with large groups in
having the team members get to know each other (i.e. working together to solve a
problem or reach a goal). In addition, the structured environment has some of the same
benefits to the respective groups in getting to know each other.

5 Sample discussion questions

As a class, the discussion resulted in a deeper understanding of process improvement
than they get from traditional lectures alone. Although this task was relatively minor,
everyone needed to work together to obtain the goal regardless of whether the experiment
was done in a structured or unstructured environment. Some of the students were
followers and some were leaders. Below are some possible questions to ask students to
help facilitate discussion:

- Did you think you could improve on your time?
  Most students believe that improvement on time is a difficult task. Students are more
  likely to say that it was easy initially and then realised that it became more difficult
  as diminishing returns appears to set in. Once they are able to discuss with one
  another different strategies to implement a new time, they are willing to try a new
  method to improve on their time.

- Did you think you could improve on your time by 25%?
  Trying to cut a time by 25% can seem like a huge and sometimes impossible task
  when you are getting closer to the end of the trials. Encouragement is helpful at this
  stage and to reiterate that it is possible to achieve a 25% decrease in time. When they
  have made that one breakthrough in improving the process, students may feel like
  the next breakthrough is harder or even impossible (i.e. continuous improvement).
• What were some of the risks to the current process?

Risks of dropping the ball may vary for a number of reasons (e.g. the class, room and student order). The more frequent risks (of dropping the ball) are students not saying their number or having to make long throws/catches. In both versions of the experiment, students tend to describe their first process improvement by managing or mitigating this risk.

• How did you as a group look to improve the process?

This is an extremely important question to ask the groups because it demonstrates the entire process improvement experiment. This question allows the students to explain and understand the different methods that the groups came up with to achieve the various goals. This question also allows the instructor to highlight various topics that you may want to emphasise.

• How many different processes did you come up with before getting to the one that you presented to the class (structured environment)?

In the structured environment, the students must discuss various proposals to improve on the process. They do not get the feedback those students in the unstructured environment experience. As such, students in the structured version of the experiment must discuss a variety of issues that led to their proposed process.

• How did you decide on a leader(s)?

Deciding on a leader seems to vary between groups, but more likely the leaders tend to speak up on their own and voice their opinions. Allowing the group to work out who will emerge as the leader or leaders illustrates other process improvement topics. For example, this experiment (especially the unstructured version) requires some inherent leader selection process, which can and usually changes over the course of the experiment. The question often leads to much discussion on how the students perceived the leader(s).

6 Concluding remarks

The main objective of this experiment is for students to gain a deeper and more practical understanding of process improvement then they would get from the presentation of traditional lecture. Both versions of the experiment illustrate how working as a group and sharing ideas allows for speedy and cohesive improvement. Students are given the opportunity to act as a group to gain a better understanding of how process improvement works in an applied setting. This experiment is useful, flexible and beneficial to students in covering a variety of topics related to process improvement, leadership, group dynamics, teamwork, to name a few. Moreover, the experiment is easy to implement and requires little in the way of preparation time and supplies.
References