THE JUICE SPC GAME:
AN EXCEL BASED SIMULATION EXERCISE

Christopher M. Scherpereel
Northern Arizona University
Chris.Scherpereel@nau.edu

ABSTRACT

The operations management discipline has been incorporating experiential exercises into their pedagogy for decades. From the beginning, these exercises used direct hands-on interactions during face-to-face instruction to facilitate learning, but changes in delivery (remote, blended) and technology (computer) have offered new opportunities. One of the most popular of these early experiential exercises used in operations management was developed by William Edwards Deming, called the red bead experiment, which facilitated student understanding of several quality control concepts. Some attempts have been made to create computer simulations to replicate the red beads experiment, but until the creation of the Juice SPC Game, none took advantage of the technology to provide a contextual experience in a computer based simulation. Motivated by COVID restrictions and a rapid movement to more remote learning modalities, I developed the Juice SPC game. Using Excel VBA as the development platform, I created the game to help students better understand how to create, monitor, and interpret control charts in the context of a juice bottler. Initial introduction of the simulation, during the fall 2021, showed student SPC learning gains in subject matter attitude, skills, understanding, and integration.

INTRODUCTION

Operations management, OM, is a subject in which students tend to struggle. There are a number of reasons for students' struggles identified in the literature, including the need for: solving problems in a complex environments (Costantino, Di Gravio, Shaban, & Tronci, 2012); critical thinking in the evaluation of competing objectives (Miyaoka, Ozsen, Zhao, & Cholette, 2018); understanding probability and statistics (Balakrishnan & Oh, 2005); and solving quantitative based problems (Bicheno, 2014). In addition to these struggles, students have very little experience in a company's operations and applying learning in context. Because OM has a skill component, a student may know how to calculate utilization, control limits, and safety stock levels on an exam, they still struggle to apply this knowledge in a realistic context, where decisions interact and an uncertain environment does not match the calculation's underlying assumptions (Leitão, Navarro, Cameira, & Silva, 2021). With these struggles and a lack of motivation, from a failure to see the relevance to their future business careers (Polito, Kros, & Watson, 2004), students often are just trying to get through their OM course.

Statistical process control, SPC, is a topic in OM that continues to challenge both students and business managers (Bober & Zgodavová, 2011). Because SPC is based on probability theory, a quantitative theory that often defies intuition, SPC tends to be one of the more difficult concepts to understand and apply (Balakrishnan & Oh, 2005). Best practices suggest that lectures and explanations only provide theoretical knowledge, failing to provide the skills required for actual application (Burch et al., 2019). Students fail to link the OM concept with the application in context (Costantino et al., 2012). I have developed a simulation based experiential exercise that provides the application context for understanding SPC.

INTRODUCTION TO STATISTICAL PROCESS CONTROL

According to Woodall (2000), SPC consists of methods for understanding, monitoring, and improving manufacturing processes and service operations. A poor grasp of SPC often results in misuse and significant costs for companies (Wachs, 2005). Thus, teaching the proper use of SPC is critical in an OM course.

Central to understanding SPC is understating how variation in specific quality characteristics effects a process. There are two types of variation to consider, common and assignable. Common variation results from the inherent nature of the process and cannot be changed without modifying the process itself. The cause of common variation cannot be identified outside of the process. Assignable variation is the result of a disruption to the process and a cause can be identified and perhaps addressed. To identify the type of variation, control charting, the primary tool of SPC, is used. Control charting is based on probability theory and is used to signal when assignable variation may be present. Practically, control charting is employed to prevent overreaction and underreaction by the decision maker. Control charts check process stability and distinguish when processes are in-control or out-of-control. An in-control designation indicates that the process is running normally, or the only variation in the process is common. This signals to the decision maker that no response is needed. An out-of-control designation signals to the decision maker that an investigation to determine the cause is warranted, and an attempt to find an assignable cause should be undertaken.

CURRENT METHODS FOR TEACHING STATISTICAL PROCESS CONTROL

SPC is usually taught as part of an introductory OM course. Because time is extremely limited in these OM survey courses, an attempt is made to communicate the SPC concept efficiently using traditional lecture and textbook based problems. Lectures tend to be an efficient modality, and let the lecturer be the sole source of information to avoid confusion of difficult ideas. Unfortunately, lectures are very taxing on the students. To get the most out of lectures, students must take detailed notes, a skill that is not common with this generation of students (O'Leary, 2017). Students learning in this environment are dependent on the lecturer and lack self-directed learning skills needed in the job market (Kicken, Brand-Gruwel, Van Merriënboer, & Slot, 2009).

A textbook problem typically includes only the information needed to solve the problem in an easy to read format. A textbook problem often has little context and relevance to the student. Given the lack of most students' OM experience, they may find it difficult to get past the problem solving process and terminology, and never internalize an understanding of the concept. Thus, the topic of SPC just becomes another academic problem solving method. Previous studies have indicated that increasing the number of textbook problems solved, shows little correlation with conceptual understanding (Kim & Pak, 2002). The traditional teaching methods may convey information efficiently but fail to effectively teach SPC conceptual understanding.

EXPERIENTIAL EXERCISES FOR TEACHING STATISTICAL PROCESS CONTROL

OM teachers have long recognized the ineffectiveness of the traditional lecture and textbook based instruction, and when practical, have turned to more experiential based delivery. Experiential exercises have been used by the operations management discipline to introduce and motivate students in their introductory OM courses (Ammar & Wright, 1998). The literature describes several experiential exercises focused on teaching SPC and control charting (Coy, 2016). Arguably the first experiential SPC exercise was introduced by William Edwards Deming (1986), consisting of two demonstration experiments called red beads and funnel. The success of these demonstration experiments and the recognized value of experiential learning, has spurred the development of SPC simulation exercises.

Variations in the lengths of string (Fish, 2007), distance of coin travel (Sumukadas, Fairfield-Sonn, & Morgan, 2005), accuracy of catapulted tennis balls (Sun & Gao, 2015), dice rolls (Jones, Hawkins, & Smith, 2008), coin tosses (Chow, Howard, & Lambe, 2008), flight times of paper helicopters (D. J. Johnson, 2011), dimensions of paper squares (Coy, 2016) and weight of M&Ms in bags (Lembke, 2016) have been used to generate variable data for control charting, specifically, for x-bar and R control charts. Rarely are these exercises designed to generate attribute data for SPC p charts. To generate attribute data the original red bead experiment (Deming, 1986) and using M&M color (Fish & Braunscheidel, 2012) remain the most widely used exercises.

These SPC exercises are either used as demonstrations or as hands-on experiential activities in a traditional face-to-face classroom. Students experience both common and assignable variation and then manually generate the relevant control chart. Thus, the primary learning objective of all these exercises is the construction of control charts. Unfortunately, these games fail to deliver a realistic context and visual experience to motivate student learning. The Juice SPC Game was developed to provide a relevant context, a simple visual interface, and a tool for practicing SPC decision making.

THE JUICE SPC GAME LEARNING OBJECTIVES

The initial implementation of the Juice SPC Game was for a core undergraduate operations management course taken by all business majors. Therefore, the learning objectives described below do not take full advantage of all the capabilities being developed in the simulation. After participation in the Juice Capacity Game, undergraduate operations management participants should be able to:

1. Differentiate between creating, monitoring, and interpreting control charts
2. Create x-bar, r, and p charts for a process in-control
   a. Calculate centerlines (x-barbar, R-bar, and p-bar) from raw data
   b. Calculate upper and lower control limits
3. Plot control chart data on existing control charts to monitor a process
4. Identify common and assignable variation in data (Interpretation)
   a. Identify out-of-control samples
   b. Identify runs (8 samples above or below the centerline)
   c. Identify trends (7 samples steadily increasing or decreasing)
5. Make appropriate decisions to address assignable cause

THE JUICE SPC GAME DESIGN

The Juice SPC Game is developed using an Excel VBA platform to be as intuitive as possible (Wood, 2007). Users have access to only the information needed, so the simulation complexity increases as the user successfully progresses through the required tasks. The context is a juice bottling company that is franchising its process to a new location and is presented as follows:

You are the quality manager of an orange juice bottling line. The current line is located in the Netherlands and bottles 0.33 liter bottles of quality juice products. The Netherland bottling line has implemented a process that delivers high quality juice as judged by its customers and therefore is considered the standard for all the company's future lines. Your task is to create control charts for the Netherland operation and then use those control charts to setup a similar process on a new franchised American based bottling line. There are two major areas of concern in the bottling process: the bottle fill level, and juice color.

Because of process variation, each bottle is filled to approximately 0.33 liters. The fill level variation in the Netherland bottling line is acceptable to customers (i.e., customers do not notice the difference between bottles that are under and overfilled), and will not impact the ability to sell the resulting product. Knowing that fill level is a continuous variable, you will need to create both X-bar and R charts from data collected from the Netherland bottling line, to establish the standard for the mean fill level and the variation (e.g., Range) in fill level, for the new American franchise. Similarly, juice can have the attribute of being colored orange or green. Due to raw material quality and natural process variation, some green juice will be produced and have to be discarded at final inspection. The Netherland line has an acceptable level of green juice and data collected from this process can be used as a process standard for the new American franchise. Thus, before being allowed to open the American franchise, you will have to create three control charts: x-bar (for fill level), R (for fill variation), and p (for an acceptable proportion of green juice).

Once the standard process in the Netherlands plant has been documented on the three control charts, you will be allowed to start the American franchise. As a franchise owner, you want to make sure that you are running the same standard process as the original Netherland plant. To do this you will need to collect data from the American bottling line and plot it on the control charts generated from the Netherland data. If any of the control chart plots reveal a quality issue; out-of-control sample, a run, or a trend; you must make decisions in an attempt to bring the process into control.

To complete the proper setup of the franchised American bottling line, you will need to complete 10 scenarios. Because of natural/random variation, you may have to make several sets of decisions to bring the process into control (if it is not already in-control). Having brought all scenarios into control (and recording those results), you will be promoted to Chief Operations Officer (COO) of the new American franchise with an annual salary of $450K.

The Netherland plant is configured to generate data for a process in-control. Students are given instructions, in Appendix A, to configure the sample size, number of samples, and run the simulation. Running the simulation will generate all the raw data needed to calculate the centerline and control limits for the three control charts: x-bar, r, and p. Visually, the students see both the variable data, fill level, and attribute data, orange or green, for the samples configured, see Figure 1 for Netherland plant interface.
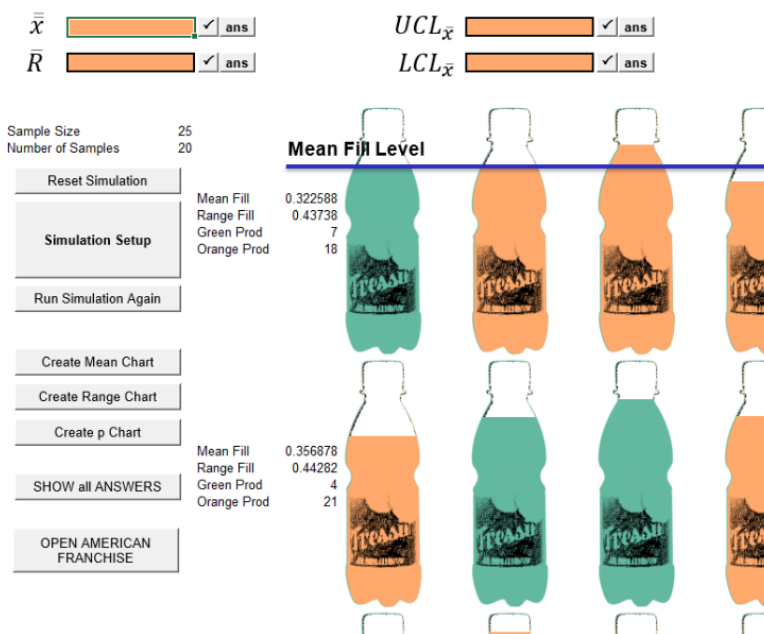

Figure 1: Netherland plant interface (Note – ALL figures will be moved to end of document after acceptance)

Using the information from the Netherland plant simulation, students can calculate and input the control chart parameters, getting help and feedback regarding the calculations. Figure 2 shows sample help and a correctly calculated value.

Students can also show the relevant control charts for the in-control (stable) process, see Figure 3. The control chart is generated using the correct control chart parameters, which the student is required to input.
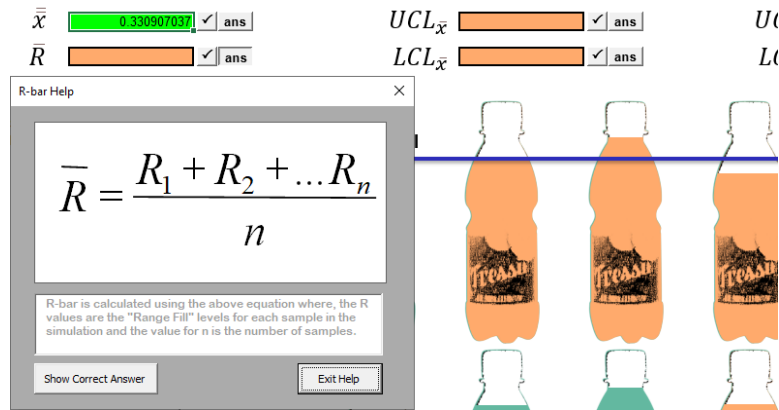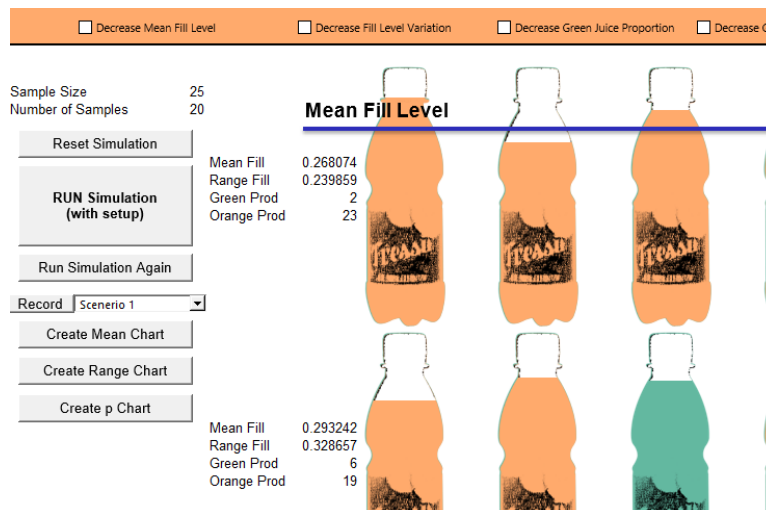
Figure 2: Netherland plant calculations
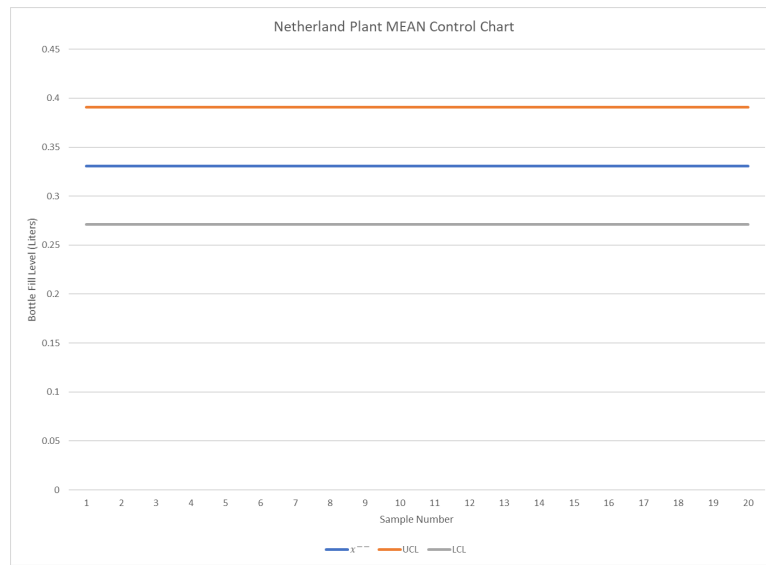
Figure 3: Netherland plant control chart example

After all calculations are correct, the franchise operation, located in America, can be opened using the "OPEN AMERICAN FRANCHISE" button in Figure 1. A new screen will become available to simulate the American plant operations under a variety of unknown scenarios. Visually the American plant generates data very similar to the Netherland plant, see Figure 4, however, the process cannot be assumed to be in-control and will need to be compared using the stable Netherland plant control charts.


Figure 4: American plant interface

The data generated from each American plant simulated scenario can be plotted on the Netherland plant control charts and out-of-control conditions identified. If all the control charts are in-control, the result can be recorded for grading. If any of the control charts have an out-of-control condition, indicating the potential for an assignable cause, the student can make appropriate decisions to bring the process back in-control and rerun the scenario to check if the decision(s) were corrective. Figure 5 shows an out-of-control condition, and would signal an action by the decision maker. The student receives feedback on the out-of-control conditions shown in the control chart.
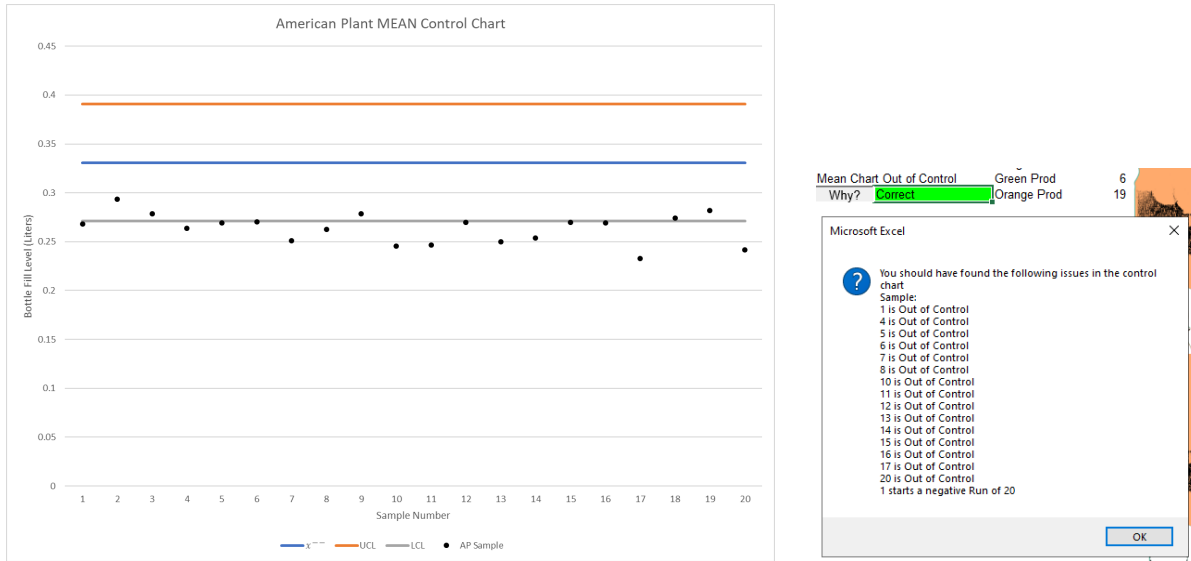
Figure 5: American plant control chart and identification of control condition

Possible decision are shown in Figure 6. All decisions have help popups and provide feedback.
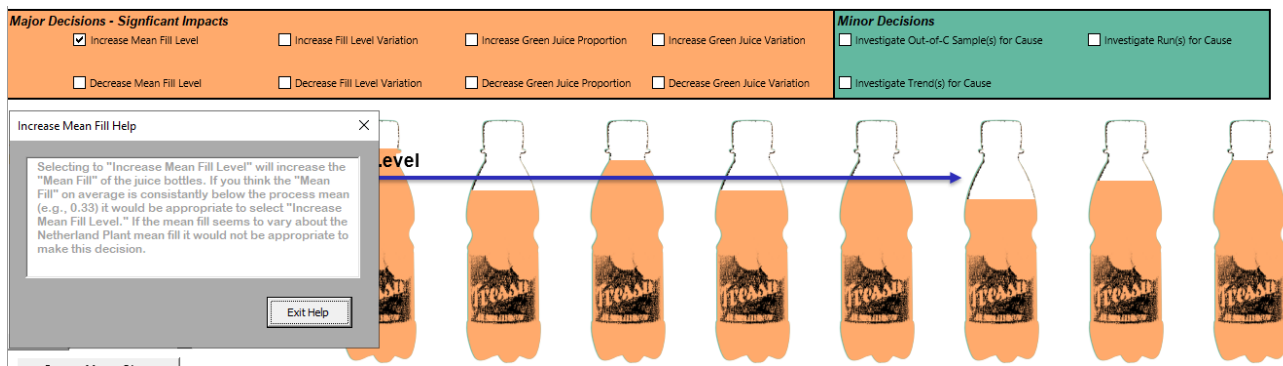
Figure 6: American plant decisions

The Juice SPC game is completed when the instructor assigned scenarios, defaulted at 10, are all brought into control by the appropriate decisions. However, the real power of this simulation is that it provides a sandbox for users to practice the key concepts of SPC.

STUDENT RESPONSE

ABSEL has produced almost 50 years of research focused on justifying the advantages of experiential learning pedagogies from a learning, attitudinal, or behavioral perspective (Anderson & Lawton, 2009). Despite the lack of rigorous empirical studies demonstrating the effectiveness of experiential activities (Girard, Ecalle, & Magnan, 2013; Gosen & Washbush, 2004), many studies claim to confirm their potential to enhance learning. Burch et.al. (2019) performed a metanalysis identifying 89 studies over a 43 year period that showed students experienced superior learning outcomes from experiential based pedagogies and reported 0 studies where a negative effect was observed.

Even with the confirmation of effectiveness of the experiential learning modality, there remain sceptics and concerns (Lewis & Williams, 1994; Wharton & Parry, 2003). Some of these concerns result from issues with research design and measurement (Gosen & Washbush, 2004). In assessing the impact of experiential learning it is important to be clear regarding the

limitations, because most studies of this nature are case studies and not controlled experiments. Kirkpatrick and Kirkpatrick (2006) present an appealing taxonomy of research for training assessment that can easily be applied to experiential learning. Their taxonomy has four levels of evaluation focusing on impact: 1. participant reaction, the lowest level, assesses whether a participant liked the experiential exercise and thus, provides feedback on satisfaction; 2. attitude changes, attempts to measure an increase in knowledge or skill resulting from the experience; 3. behavioral changes, evaluates whether the new knowledge or learned skills are applied outside of the experience; and 4. results, measures the impact of the experiential exercise on the participant's organization and job performance. In addition to impact, the rigor of the study can range from case based to a controlled experimental design, with the former accounting for the vast majority of the research (Leitão et al., 2021).

In assessing the Juice SPC Game, I focus the impact measurement on participant reaction (level 1) and attitude changes (level 2) in a single case study situation. Upon completion of the game, a reaction survey was anonymously administered to all students. This survey was based on a modified version of the Student Assessment of their Learning Gains (SALG) instrument developed by Seymour et.al (2000). The SALG survey instrument uses a five-point Likert-style scale to measure perceived gains in attitude, skills, understanding, and integration. The instrument was developed based on research that showed that students are able to make realistic appraisals of their gains (Seymour et al., 2000). SALG has been tested for validity and reliability through multiple studies in a variety of disciplines (Danko, 2020).

The Juice SPC game was introduced, during the fall term 2021, in a core introductory operations management class. Following completion of the game, 104 students were asked to complete a SALG based survey regarding the perceived gains from their experience. Seventy students volunteered to participate in the survey. Results indicated that students gained understanding from the exercise, with the greatest gain coming in complex problem solving, a key objective of my OM course (Figure 7).
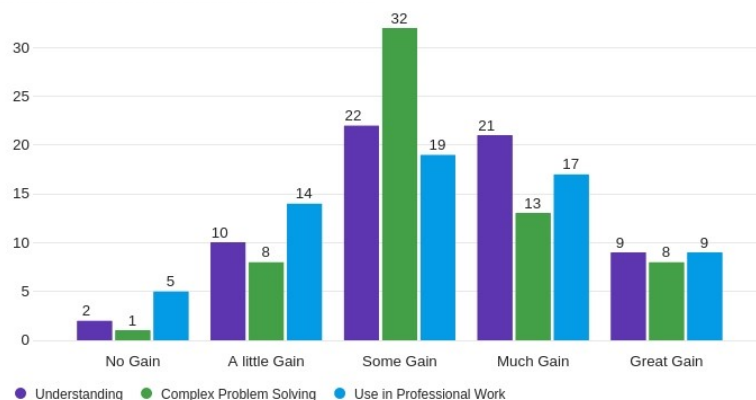

Figure 7: Gains in understanding from the Juice SPC Game

Regarding the Juice SPC Games objectives, students indicated that they gained skills in creating, monitoring, and interpreting control charts (Figure 8).
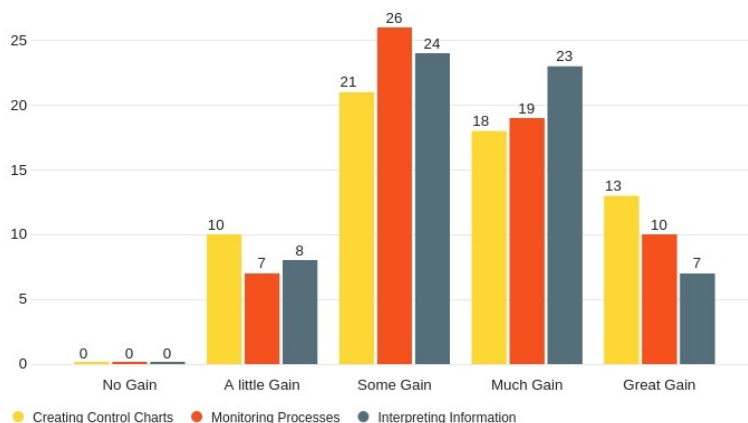

Figure 8: Gains in creating, monitoring, and interpreting skills from the Juice SPC Game

Specifically, skills in recognizing SPC issues were the greatest. This is an integrative skill that is challenging to communicate using a traditional lecture and textbook modality (Figure 9).
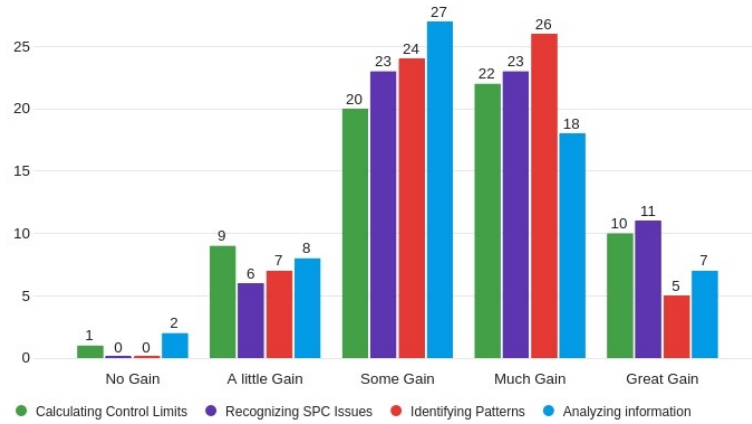
Figure 9: Gains in calculating, recognizing, identifying, and analyzing skills from the Juice SPC Game

While students indicated some gain in enthusiasm for the SPC subject, they experienced greater gains in usefulness and connection to the real world (Figure 10).
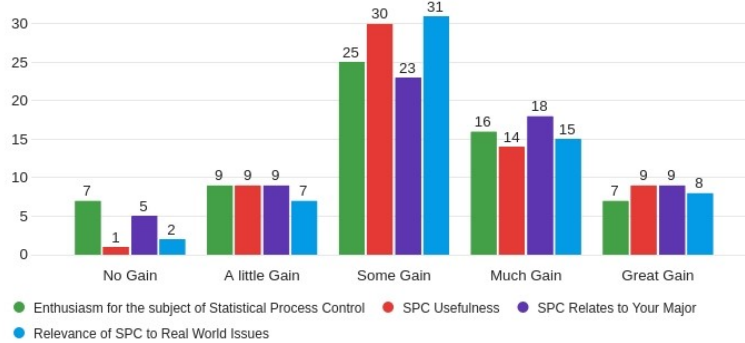
Figure 10: Gains in attitude from the Juice SPC Game

Finally, integration and transfer of learning are the ultimate goals of education (Hajian, 2019). The data indicate that students recognized perceived gains along this dimension (Figure 11).
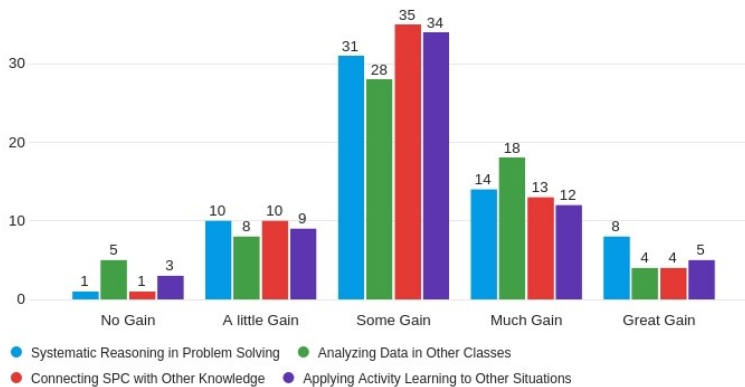
Figure 11: Gains in integration from the Juice SPC Game

DISCUSSION

There are three areas that students struggle with in SPC. First, it is difficult to understand when the data should be used to create a control chart and when it should be plotted on a control chart. This is the difference between creating control charts for the Netherland plant and monitoring control charts for the American Plant. Secondly, understanding the distinction between sample size and number of samples can be confusing. This misunderstanding leads to the inaccurate calculation of control limits. Thus, practicing with different Netherland plant configurations helps to clarify this distinction. Finally, making decisions based on control chart information is difficult to learn with static textbook examples. The SPC game specifically asks participants to interpret the American plant control data and make appropriate decisions to bring an out-of-control process into control. The receipt of immediate feedback on SPC decisions is not possible with traditional textbook problems. Thus the SPC game was designed to address these specific learning gaps and achieve the objectives outlined previously.

The game was designed to offer a contextual experience and to achieve specific objectives, but were these accomplished? The results from the SALG survey gives preliminary confirmation to the simulations value. Students clearly indicated they gained skills, understanding, and integration of the statistical process control concepts. Because fall 2021 was the first implementation of SPC game and the game was still under development, a comparative study was left for future research. However, I can conjecture that a meaningful improvement over traditional pedagogy could be observed. Operations management is challenging for students because it requires critical thinking and mathematical problem solving skills. Additionally, most students lack context for understanding how OM impacts their lives (Miyaoka et al., 2018), thus their motivation for actually retaining the concepts learned is low. Students are motivated when they are learning something they value (R. Johnson, 1996). The SALG data clearly shows a gain in SPC usefulness (i.e., value), which suggests greater motivation and perhaps better retention of the concepts learned.

REFERENCES

Ammar, S., & Wright, R. (1998). Introduction to operations management: The MBA in-class experience. *Decision Line, September/October*, 3-6.

Anderson, P. H., & Lawton, L. (2009). Business simulations and cognitive learning: Developments, desires, and future directions. *Simulation & Gaming, 40*(2), 193-216.

Balakrishnan, J., & Oh, S. L. (2005). An interactive VBA tool for teaching statistical process control (spc) and process management issues. *INFORMS Transactions on Education, 5*(3), 19-32.

Bicheno, J. (2014). Fun and games in Operations Management: running a course with games every week? *International Simulation and Gaming Yearbook*, 123.

Bober, P., & Zgodavová, K. (2011). *Educational web tool for statistical process control.* Paper presented at the 2011 14th International Conference on Interactive Collaborative Learning.

Burch, G. F., Giambatista, R., Batchelor, J. H., Burch, J. J., Hoover, J. D., & Heller, N. A. (2019). A meta-analysis of the relationship between experiential learning and learning outcomes. *Decision Sciences Journal of Innovative Education, 17*(3), 239-273.

Chow, A. F., Howard, J. C., & Lambe, N. J. (2008). Teaching variation using an interactive classroom activity. *Decision Sciences Journal of Innovative Education, 6* (2), 305-311.

Costantino, F., Di Gravio, G., Shaban, A., & Tronci, M. (2012). *A simulation based game approach for teaching operations management topics.* Paper presented at the Proceedings of the 2012 Winter Simulation Conference (WSC).

Coy, S. P. (2016). Manufacturing squares: An integrative statistical process control exercise. *Decision Sciences Journal of Innovative Education, 14*(3), 285-300.

Danko, T. T. (2020). Perceptions of Gains Through Experiential Learning in Homeland Security and Emergency Management Education. *Journal of Homeland Security Education, 9*.

Deming, W. E. (1986). Out of the crisis: Quality. *Productivity and Competitive Position, Massachusetts, USA*.

Fish, L. A. (2007). Statistical quality control: Developing students' understanding of variable control charts using string. *Decision Sciences Journal of Innovative Education, 5*(1), 191-196.

Fish, L. A., & Braunscheidel, M. J. (2012). Proving the Usefulness of Demonstrations: Using M&M's to Develop Attribute Control Charts. *Decision Sciences Journal of Innovative Education, 10*(2), 263-270.

Girard, C., Ecalle, J., & Magnan, A. (2013). Serious games as new educational tools: how effective are they? A meta-analysis of recent studies. *Journal of Computer Assisted Learning, 29*(3), 207-219.

Gosen, J., & Washbush, J. (2004). A review of scholarship on assessing experiential learning effectiveness. *Simulation & Gaming, 35*(2), 270-293.

Hajian, S. (2019). Transfer of Learning and Teaching: A Review of Transfer Theories and Effective Instructional Practices. *IAFOR Journal of education, 7* (1), 93-111.

Johnson, D. J. (2011). Using paper helicopters to teach statistical process control. *Decision Sciences Journal of Innovative Education, 9*(2), 299-306.

Johnson, R. (1996). The adult student: Motivation and retention. *The American Music Teacher, 46*(2), 16.

Jones, M. P., Hawkins, R. S., & Smith, R. (2008). Enhancing student understanding of Control Charts using a dice activity. *e Technology Interface, Spring*.

Kicken, W., Brand-Gruwel, S., Van Merriënboer, J., & Slot, W. (2009). Design and evaluation of a development portfolio: how to improve students' self-directed learning skills. *Instructional Science, 37*(5), 453-473.

Kim, E., & Pak, S.-J. (2002). Students do not overcome conceptual difficulties after solving 1000 traditional problems. *American Journal of Physics, 70*(7), 759-765.

Leitão, T. M., Navarro, L. L. L., Cameira, R. F., & Silva, E. R. (2021). Serious games in business process management: a systematic literature review. *Business Process Management Journal*.

Lembke, R. S. (2016). Process variability and capability in candy production and packaging. *Decision Sciences Journal of Innovative Education, 14*(3), 301-314.

Lewis, L. H., & Williams, C. J. (1994). Experiential learning: Past and present. *New directions for adult and continuing education, 1994*(62), 5-16.

Miyaoka, J., Ozsen, L., Zhao, Y., & Cholette, S. (2018). Experiential Undergraduate Operations Management Course Engages Students. *Journal of Supply Chain and Operations Management, 16*(3), 219.

O'Leary, D. (2017). Picture This: Tackling the Latest Trend in Digital Note Taking. *Law Tchr., 24*, 2.

Polito, T., Kros, J., & Watson, K. (2004). Improving operations management concept recollection via the Zarco experiential learning activity. *Journal of Education for Business, 79*(5), 283-286.

Seymour, E., Wiese, D., Hunter, A., & Daffinrud, S. M. (2000). *Creating a better mousetrap: On-line student assessment of their learning gains.* Paper presented at the National Meeting of the American Chemical Society.

Sumukadas, N., Fairfield-Sonn, J. W., & Morgan, S. (2005). Ready-to-use simulation: DEMYSTIFYING STATISTICAL PROCESS CONTROL. *Simulation & Gaming, 36*(1), 134-145.

Sun, W., & Gao, Y. (2015). *Teaching Statistical Quality Control by Applying Control Charts in the Catapult Shooting Experiments*. Paper presented at the ASEE Conferences, Seattle, Washington. https://peer.asee.org/24826

Wachs, A. (2005). Do You Use SPC Correctly? Misapplication of Statistical Process Control Can Damage Your Operations. *Manufacturing Engineering, 134*(3), 159-168.

Wharton, R., & Parry, L. (2003). The good, the bad, and the ugly: Using experiential learning in the classroom. *Journal of the Scholarship of Teaching and Learning, 3*(3), 56.

Wood, S. C. (2007). Online games to teach operations. *INFORMS Transactions on Education, 8*(1), 3-9.

Woodall, W. H. (2000). Controversies and contradictions in statistical process control. *Journal of quality technology, 32*(4), 341-350.

APPENDIX A
INSTRUCTIONS

Task 1: Set up (CREATE) control charts from the Netherland bottling plant process

1. Open the Deming Control Game (version 1.65).xlsm

2. The simulation will ask for a password – enter "student"

3. The simulation is navigated by Excel tabs located at the bottom of the screen – The opening screen is the "Netherland Plant" tab. The other visible tab contains the "Factor Table" needed to calculate the control limits.

4. The simulation should already be reset, however, if needed, you can click on the "Reset Simulation" button.

5. Click on the "Simulation Setup" button

   a. A popup allows you to change the Sample Size and Number of Samples – the default of 25 and 20 respectively, is acceptable.
   b. After these values are set, click on "OK"
   c. The simulation will run, showing the desired number of samples with the indicated sample size. All the data necessary to calculate the ten (10) values along the top of the screen will be generated by the simulation.

6. Calculate the ten (10) values needed to create the control charts, found in the orange boxes along the top of the screen 9 (round to three digits after the decimal e.g., 0.000)

   a. The check mark next to the orange input box can be used to check your answer.
   b. The "ans" button will provide a help box with the equations and if selected the correct answer.
   c. The "SHOW all ANSWERS" button will fill in the correct answers for all 10 required inputs. If you have practiced enough and want to move on to the second part of the simulation (Task 2), without having to perform the calculations, you can click this button.
   d. NOTE: even though you can get all the answers without attempting the calculations, you need to understand how to do these calculations on the exam and this simulation allows you an opportunity to practice.

7. To view the actual control charts generated by the simulation samples for the Netherland Plant click on the related button

   a. "Create Mean Chart" will generate the mean control chart for the data in a new tab at the

bottom of the screen. Select the "Netherland Plant" tab to return to choose other options.

    b. "Create Range Chart" will generate the range control chart for the data in a new tab at the bottom of the screen. Select the "Netherland Plant" tab to return to choose other options.

    c. "Create p Chart" will generate the p control chart for the data in a new tab at the bottom of the screen. Select the "Netherland Plant" tab to return to choose other options.

8. Once you fully understand the *creation of control charts* (and all answers are correct), you can click on the "OPEN AMERICAN FRANCHISE" button to continue the simulation. If everything is ready, a popup will let you open the American Plant, a new tab will be created called "American Plant", and that tab will be activated.

Task 2: Check (MONITOR) the new American Plant process data for control

1. On the "American Plant" tab you will be presented with another simulation.

2. The simulation should already be reset, however, if needed, you can click on the "Reset Simulation" button.

3. Click on the "RUN Simulation (with setup)" button

    a. A popup allows you to change the Number of Samples – the default is the same as was used in the Netherland Plant, and can be left at the default values.

    b. After these values are set, click on "OK"

    c. The simulation will run, showing the desired number of samples with the indicated sample size. Some decision options will appear at the top screen. These options will be addressed after the simulation data is plotted on the control charts.

4. The American Plant data collected can be plotted on the control charts (created from the Netherland Plant data/calculations) using the related buttons

    a. "Create Mean Chart" will plot the American Plant data on the mean control chart in a new tab at the bottom of the screen, "AP Mean Control Chart".

        i. In the upper left hand corner of the chart, you can indicate whether the data plotted indicates a process in control

        ii. After indicating your evaluation of the process control you will be taken back to the "American Plant" tab

        iii. New information on the left hand side of the screen will indicate whether your evaluation was correct.

        iv. The associated "Why?" button will provide feedback on your evaluation.

    b. "Create Range Chart" will plot the American Plant data on the range control chart in a new tab at the bottom of the screen, "AP Range Control Chart".

        i. In the upper left hand corner of the chart, you can indicate whether the data plotted indicates a process in control

        ii. After indicating your evaluation of the process control you will be taken back to the "American Plant" tab

        iii. New information on the left hand side of the screen will indicate whether your evaluation was correct.

        iv. The associated "Why?" button will provide feedback on your evaluation.

    c. "Create p Chart" will plot the American Plant data on the p control chart in a new tab at the bottom of the screen, "AP p Control Chart".

        i. In the upper left hand corner of the chart, you can indicate whether the data plotted indicates a process in control

        ii. After indicating your evaluation of the process control you will be taken back to the "American Plant" tab

        iii. New information on the left hand side of the screen will indicate whether your evaluation was correct.

        iv. The associated "Why?" button will provide feedback on your evaluation.

Task 3: Change the American Plant process if necessary

1. After creating all the control charts, you have the ability to make both minor and major decisions found along the top of the "American Plant" tab screen.

    a. If all control charts are "in control," no decisions need to be made.

     i. Click on the "Record" button next to the scenario dropdown menu (e.g., Scenario 1)

  b. If any of the control charts are "out of control," some decisions should be made to bring the process into control.

     i. Minor decisions (in green), can be used if only minor adjustments are needed to the "American Plant" process. Only a small number of out-of-control issues are seen in the control charts.

     ii. NOTE: the simulation will not let you make a minor decision that the control chart does not warrant.

     iii. Major decisions (in orange), can be used if major adjustments are needed to the "American Plant" process. Manu out-of-control issues are seen in the control charts

     iv. NOTE: the simulation will allow you to make these major decisions regardless of the chart data. Help screens will note the effect on the process.

     v. Click on "Run Simulation Again" to run the simulation with all the decisions that you have selected.

2. When all control charts are in control, Click on the "Record" button next to the scenario dropdown menu (e.g., Scenario 1)

Task 4: Repeat Task 2 and Task 3 for the other scenarios (e.g., ten scenarios need to be completed)

 a. After recording a scenario, use the scenario selection box (next to the record button) to select another scenario. All ten (10) scenarios should be completed and recorded, the order does not matter. Don't worry if you accidentally record a scenario that you are still trying to complete, the results file will keep track of all recorded scenarios.

 b. The record button creates a file on your desktop that should be submitted to your instructor. The will be named "Simulation Results.xlsx" and can be found on your desktop.