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INDIANA UPLANDS | PROUD PARTNER

Grade 9-12 STEM Challenge

It's a Numbers Game

Inspired by Yolanda, an Industrial Engineer in in the Indiana Uplands.

Published by Regional Opportunity Initiatives

GRADE 9-12 STEM CHALLENGE

It's a Numbers Game

Inspired by Yolanda, an Industrial Engineer in the Indiana Uplands.

Students will use lean manufacturing strategies to develop an optimal process.

LESSON TIMELINE

DAY 1

- Show the job shadow video, "Yolanda - Industrial Engineer" (5 minutes)
- Introduce the 5S process and lean manufacturing (10 Minutes)
- Introduce the challenge (5 minutes)
- Lead students through the game (15 minutes)
- Debrief (10 minutes)

Recommended Supplies

General Supplies (per group of 2):

- Print-out of "number workspace" handouts.
- Stopwatch
- Markers
- Spreadsheet for recording results.

This activity can also be done as a class with one handout per student.

CAREER CONNECTION AND LESSON OVERVIEW

Designing processes is a big part of an industrial engineer's day. Industrial engineers, like Yolanda, not only have to design factories, but also determine how work will be done. One approach to this is lean production, a strategy of management that aims to cut out wasted time, materials, and equipment while making sure a quality finished product goes out the door. This is important at the Bedford General Motors plant, where inefficiency can not only cost money but lead to safety issues.

Part of lean production is the concept of the 5S's: Sort, Set in Order, Shine, Standardize, Sustain. This methodology for creating processes and solving problems was developed in Japan (where the five s-words are Japanese). Though the words are slightly different in English, the outcome is the same: lean 5S is a way of setting up a workspace to make sure everything can be found easily.

IN THIS CHALLENGE, STUDENTS WILL:

- Play a simulation that demonstrates the 5S's of lean production and manufacturing.
- Draw parallels between manufacturing and their own learning processes at school.
- Learn about industrial engineering and how engineers work to create not only what is made but how it is made.

Standards

Science & Engineering Process Standards

SEPS.1 Posing Questions (for science) and defining problems (for engineering)
SEPS.2 Developing and using models and tools
SEPS.4 Analyzing and interpreting data
SEPS.5 Using mathematics and computational thinking
SEPS.8 Obtaining, evaluating, and communicating information

9-10 Employability Skills Standards

9-10.M.1 Seek and participate in challenging learning activities related to career goals.
9-10.WE.4 Demonstrate organizational skills while completing project-based learning experiences and activities.
9-10.LS.5 Able to acquire knowledge of various career clusters through exploration (field trips, jobsite tours, job shadows, mentors, etc.).
9-10.LS.8 Participate in challenging learning activities and/or coursework related to career goals.
9-10.LS.11 Able to combine concepts in different ways to create new ideas and innovative solutions.

Preparing for College and Careers

PCC-2.1 Determine roles, functions, education, and training requirements of various career options within one or more career clusters and pathways
PCC-2.2 Analyze career trends, options and opportunities for employment and entrepreneurial endeavors for selected career clusters and pathways
PCC-2.3 Evaluate selected careers and pathways for education requirements, working conditions, benefits, and opportunities for growth and change
PCC-2.4 Use appropriate technology and resources to research and organize information about careers

Planning and Implementation

IT'S A NUMBERS GAME

In this challenge, students will:

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- Draw parallels between manufacturing and their own learning processes at school
- Learn about industrial engineering and how engineers work to create not only what is made but how it is made.

Essential Vocabulary

- EFFICIENCY: How well a process avoids wasting time, energy, or materials.
- LEAN MANUFACTURING: A strategy for manufacturing or research that minimizes waste while maximizing productivity.
- PROCESS: A series of actions or steps taken to achieve a goal or outcome.
- THE LEAN 5S:
  - SORT: Eliminate what is not needed.
  - SET IN ORDER: Organize whatever is left.
  - SHINE: Clean up your work area.
  - STANDARDIZE: Create a standard set of rules for your workspace.
  - SUSTAIN: Make it a habit.

Before Class:

- Read the activity outline sheet and leader notes to become familiar with the activity.
- Gather necessary materials. Be sure that you have enough materials (the printed handouts, pens, etc) to allow students to either work individually in, one large group or in sets of two.
- Regardless of how you structure the game, make sure all students record their data for each round. Aggregate this data and encourage students to draw conclusions about their own efficiency.
- Students will run this simulation as a group with the instructor leading.

Guiding Questions

1. How do scientists, engineers, and manufacturers ensure that their workspaces are efficient?
2. This activity is a very simple way of streamlining a process. What ARE processes? How do students create them each day?
3. How can ideas like the 5S's and lean be applied to other STEM fields?

Introduction

Show students Yolanda's job shadow video. Discuss broadly that engineers, in general, solve problems. Industrial engineers, like Yolanda, not only design equipment but also processes, or ways of accomplishing things. This can include how equipment is built, how it is laid out in a factory, and how it handles raw materials. A large part of Yolanda's job is ensuring that parts are made correctly and that no defective parts leave the factory.

> "A bad system will beat a good person every time."
>
> -W. Edwards Deming

Lean manufacturing (or lean production) is a philosophy used in industrial engineering to create efficient and safe systems. It's all about eliminating waste—wasted materials, wasted movement, or wasted time. It seeks to eliminate any thing or activity that does not add value to what you're trying to accomplish. This idea may come from industrial and production work, but it's a philosophy that should sound familiar to anyone who works in a STEM field. Engineers do this, as do scientists, technicians, and anyone else who needs to create a working environment that makes their job easier.

Japanese	Translated	English	Definition
Seiri	organize	Sort	Eliminate what is not needed by separating tools, parts, and instructions from unneeded materials. Make sure the only things present are the things you need.
Seiton	orderliness	Straighten or Set in Order	Organize whatever is left by arranging and identifying parts and tools for ease of use. Lay things out in a way that makes sense.
Seiso	cleanliness	Shine	Clean up your work area! Make sure everything you're using is in working order, the instructions are legible, etc.
Seiketsu	standardize	Standardize	Create a standard set of rules for your work area based on the first 3 S's.
Shitsuke	discipline	Sustain	Make 5S a way of life by forming the habit of always following the first four S's. Decide on the optimal way to run your workspace and stick to it.

Adapted from https://asq.org/quality-resources/lean/five-s-tutorial

The 5S's of lean manufacturing are part of this. It's a method for creating a workspace that is uncluttered, organized, and safe. Any student who has spent too much time trying to find a pair of socks in the morning knows how a disorganized space can derail your day.

Think/Pair/Share Opportunity: Ask students to pair up and think of examples of processes from their daily lives.

The 5S's were originally developed in Japan but they've been translated into English as closely as possible. Each of these five S's corresponds to a step that can be taken to streamline a process and ensure that time and effort aren't wasted. Engineers, designers, machinists, maintenance technicians, scientists, and many others use 5S to streamline their work and processes.

The Challenge

Students will be given a sheet of paper with numbers printed on them. Their "job" is to cross off or strike through as many numbers as possible, from 1 to 50 in order, during their "shift" of 20 seconds. The handouts are available at the end of this packet on pages S1-S9.

There will be a new handout "workspace" for each of the 5 rounds of the game. Students should be given each sheet face down before each round.

Round 1 - What a mess!

The Set-up:
Povide the Round 1 handout to students. Ask them to leave the sheet face down until the timer is started. They will need to cross out the numbers in order starting with the number one. Make sure the students understand what they are doing.

"This sheet represents your 'workstation.' Your 'job' today is to cross off the numbers on a sheet of paper in order from 1 to 50 in your 20 second shift. Don't turn over your sheet until the timer begins. Ready? START!"

The Results:
Ask students to record how many numbers they were able to find and cross off (it will be the same as the largest number they crossed out.) Collect the students' data in a spreadsheet and find a minimum, maximum, and average number crossed out for the class.

Encourage students to think about what happened at their "job" in this round.

- Was this an easy job? What made it hard? How could it be made easier?
- What are the quality issues? Can you tell a 6 from a 9? And why would that be important?

Round 2 - Sort

The Set-up:
Provide the Round 2 sheets to students. Remind them to leave the sheets face down until the timer starts and that they must cross out the numbers in numerical order.

"Let's apply that first S: SORT! If you don't need something right now, set it aside and get it out of your way. You're going to have a new workspace for this round. This time any number higher than 50 is gone from your space. Let's see how many numbers you can cross out in order now that some of the clutter is gone."

The Results:
Collect students' data on how many numbers they were able to find and cross out now that numbers greater than 50 have been eliminated. Have the students record their own data and add it to the class spreadsheet. Discuss how the minimum, maximum, and average number crossed out in Round 2 compared to Round 1. Students should already be seeing improvement.

- Was this round easier? Why?
- What is still making this hard?

Round 3 - Straighten or Set In Order

The Set-up:
Provide the Round 3 sheets to students, where the numbers have been lined up in order but the orientation is unchanged. Remind them to leave the sheets face down until the timer starts and that they must cross out the numbers in numerical order.

"Okay, time for that second S, which can be either 'straighten' or 'set in order' (translation is seldom an exact science!) Basically, now that we've cleared out the stuff we don't need, what else can we do? Let's see if straightening up these numbers into rows helps. "

The Results:
Collect students' data on how many numbers they were able to find and cross out now that the remaining numbers are in rows. Have the students record their own data and add it to the class spreadsheet. Discuss how the minimum, maximum, and average number crossed out in Round 3 compare to Rounds 1 and 2.

- Was this round easier?
- How much improvement did you see?
- What else could we do to make this process even more efficient?

Round 4 - Shine

The Set-up:
Give students the Round 4 sheet. This time students will find that all of the numbers are not only lined up but also oriented in the same way to make them more legible. Remind them to leave the sheets face down until the timer starts and that they must cross out the numbers in numerical order.

"That third S is 'shine,' or get everything cleaned up and tidy. Our system is much better already but there's still room for improvement in the process. Let's see if getting all of our numbers oriented the same way helps."

The Results:
At this point, the students should be having a much easier time crossing out numbers in the 20 second period. Again: have students record their own data and add it to the class spreadsheet. Discuss how the minimum, maximum, and average number crossed out in Round 4 compare to Rounds 1, 2, and 3.

- What else could we do to simplify this? (many students will remark that the fonts/type styles don't need to be different.)

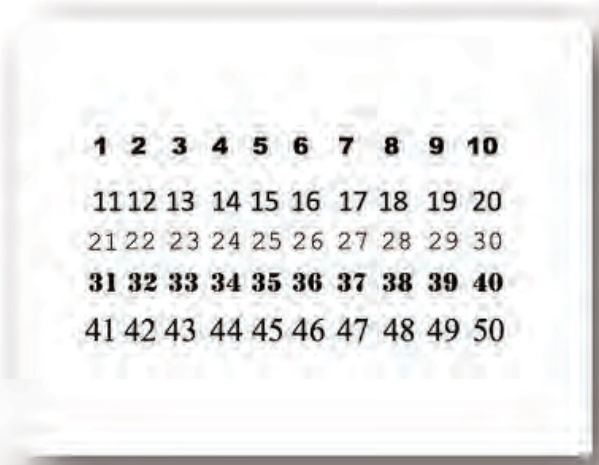
Round 5 - Standardize

The Set-up:
Provide students with the Round 5 sheet face-down. On this sheet, the numbers are presented not only in order and oriented correctly but also in similar fonts. Many students may remark, after this round, that the process is TOO easy. That's good! The point of good process design is to solve a problem or complete a challenge in the shortest time possible and as accurately as possible. The results SHOULD feel easy. Remind them to leave the sheets face down until the timer starts and that they must cross out the numbers in numerical order.

"Everything is lined up and cleaned up, but our process could still be better. Does every single number really need to be in a different style? We can implement that 4th S, standardization, to make things easier on ourselves."

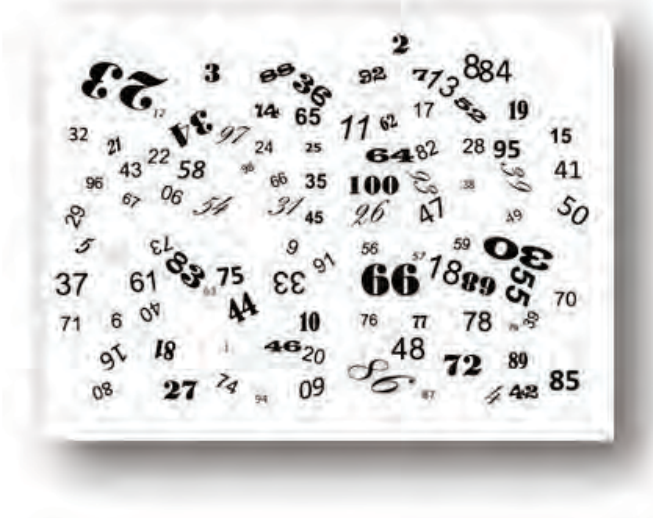
The Results:
This should be the easiest round of all for students and they may already be able to cross out nearly all the numbers in the allotted time. Record the class data and discuss.

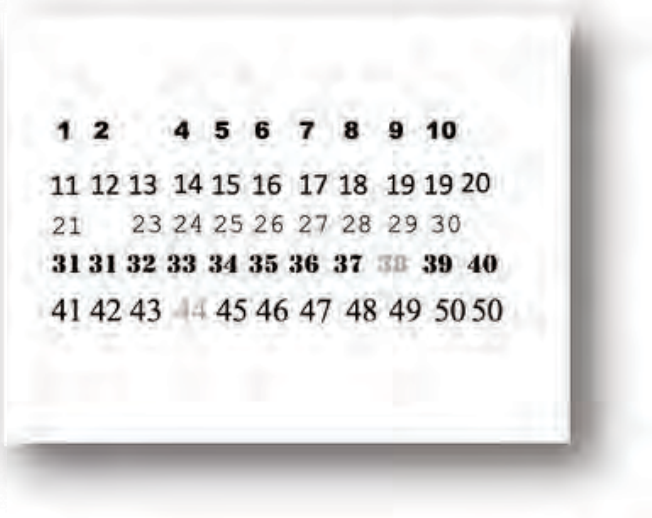
- Is there anything else that would make this process even MORE efficient?



Round 6 - Sustain

The Set-up:
Round 6 has two parts: students will first have 20 seconds to find the errors in the non-optimized “workspace” and then 20 seconds to find the quality issues in a “workspace” sorted using the 5S method. Remind them to leave the sheets face down until the timer starts. It may be helpful to do one sheet, collect the data, and then do the other.

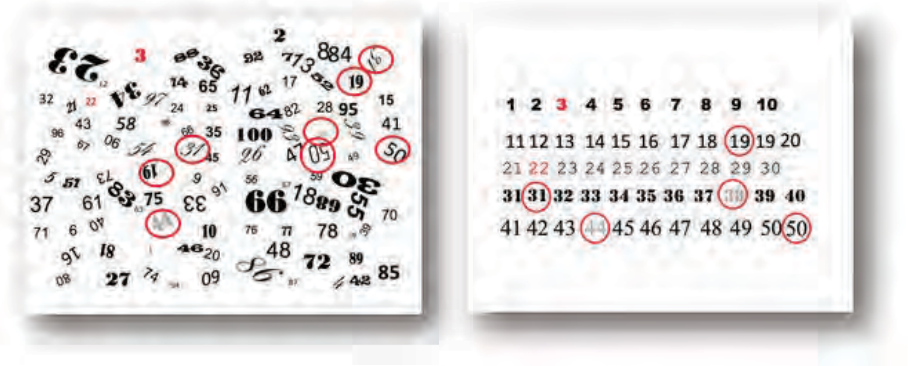




"It's not enough to come up with good processes, you have to use them as well! The last S is sustain or keep using the approach you developed. We've seen the process work: sorting out the numbers we don't need, straightening out the order, shining (tidying) up the orientation, and standardizing the format. The 5S process makes it easy to ensure the quality of your work. On your next job, you're looking for errors in your materials. Some of your numbers are missing, some of them are duplicated, and some of them are the wrong color. You'll have 20 seconds to find the errors in a version of your workspace that has NOT been optimized with the 5S process and one that has."

The Results:
Students probably found it difficult to find the errors on the disorganized "workspace" of numbers compared to the sorted, organized 5S-ified list. There are actually 7 mistakes in their materials:

1. Missing 3
2. Duplicate 19's
3. Missing 22
4. Duplicate 31's
5. Wrong color 38 (grey)
6. Wrong color 44 (grey)
7. Duplicate 50's



The same things are missing, duplicated, or changed in both versions. In their initial workspace, things were in a state of disarray. There are excess numbers, a large area to search, it is cluttered, and it takes way too long to find what's needed. It is very difficult to identify the problems. After optimizing their process it is much easier to find what you need. The materials in question (the numbers) are only the ones necessary and they are organized in a way that makes sense.

Help your students reflect on the 5S process and what it means for engineers and other STEM professionals.

- Which version of your workspace made it easier to find quality issues? Which version do you think you would prefer to have as an engineer?
- How do you think engineers and scientists might use the 5S's to make their work easier?
- Where could processes like 5S be used in students' daily life? In other classes?
- What other applications of lean processes can you think of?

Discuss and Report

Once students have finished, prompt them for a discussion of the activity and its role in engineering and problem solving.

1. Which step of the 5S strategy made the biggest difference in ordering your numbers
2. Why might an engineer want to implement lean 5S in their workspace?
3. What are some processes in your daily life that could be improved using 5S?

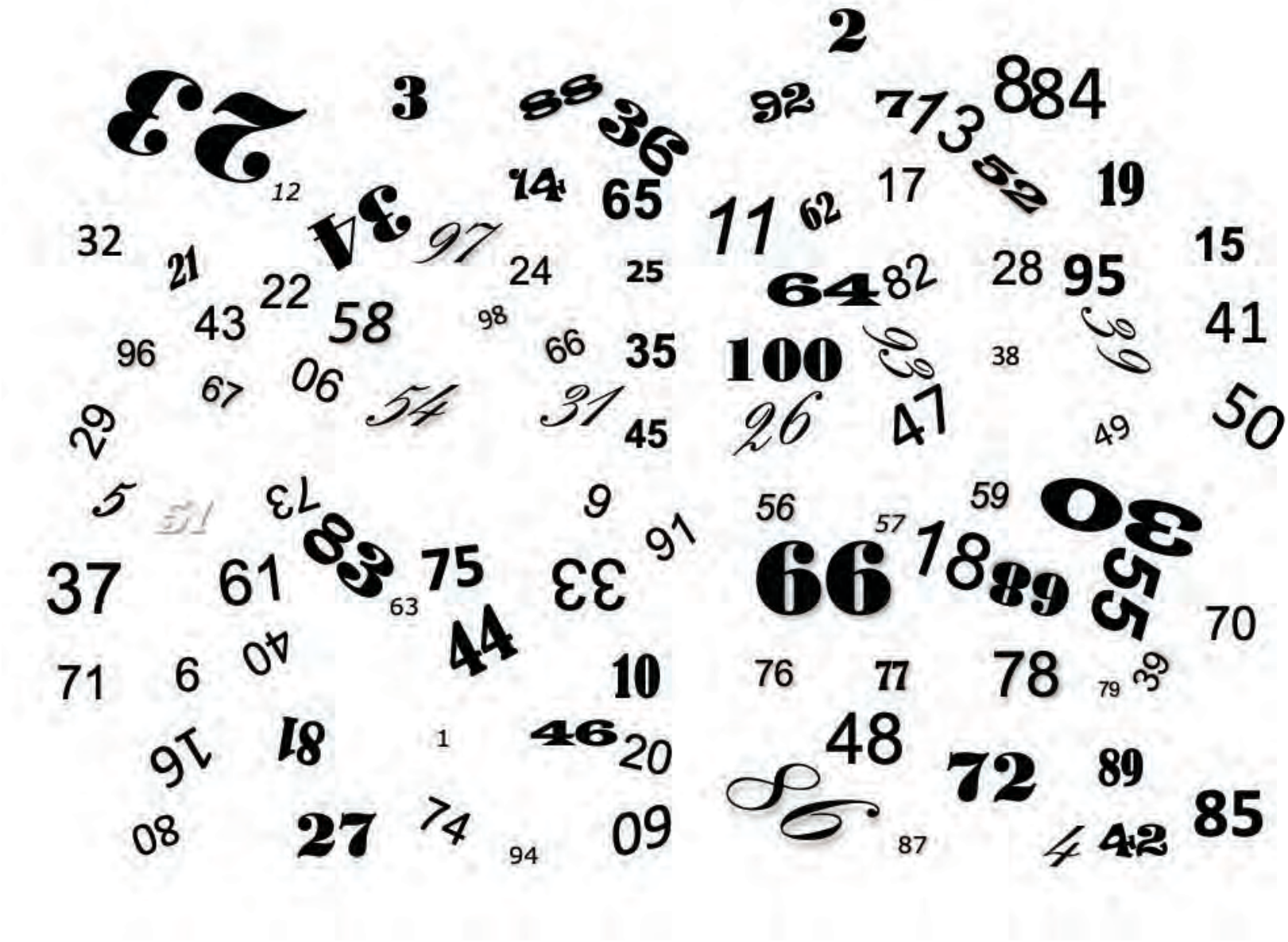
Career Exploration and Extension

Have students apply the 5S approach to something in their academic life. How could they redesign or reorganize their lab or classroom using 5S? How might this help them learn?

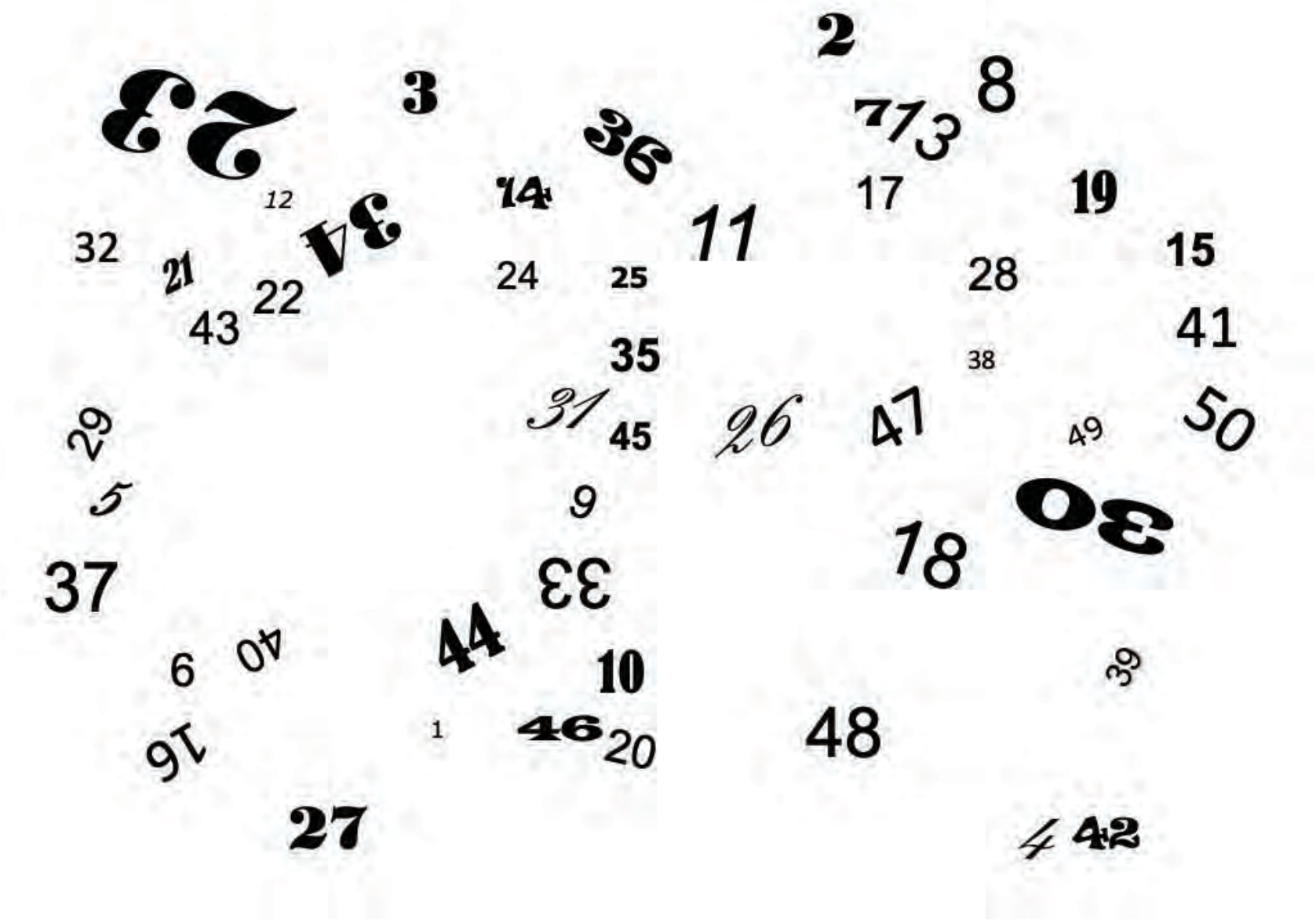
Prompt students to think about and research what a career as an industrial engineer might entail.

- What does an industrial engineer do all day? What does Yolanda do as part of her daily duties?
- What kind of training would a student need to become an industrial engineer? What about an engineer in general? What other jobs might have similar skill sets?
- Are jobs like Yolanda's in demand? Will more people be hired for engineering jobs in the future?
- What kind of education is needed to be an industrial engineer? Where could a student be trained locally for a career in engineering

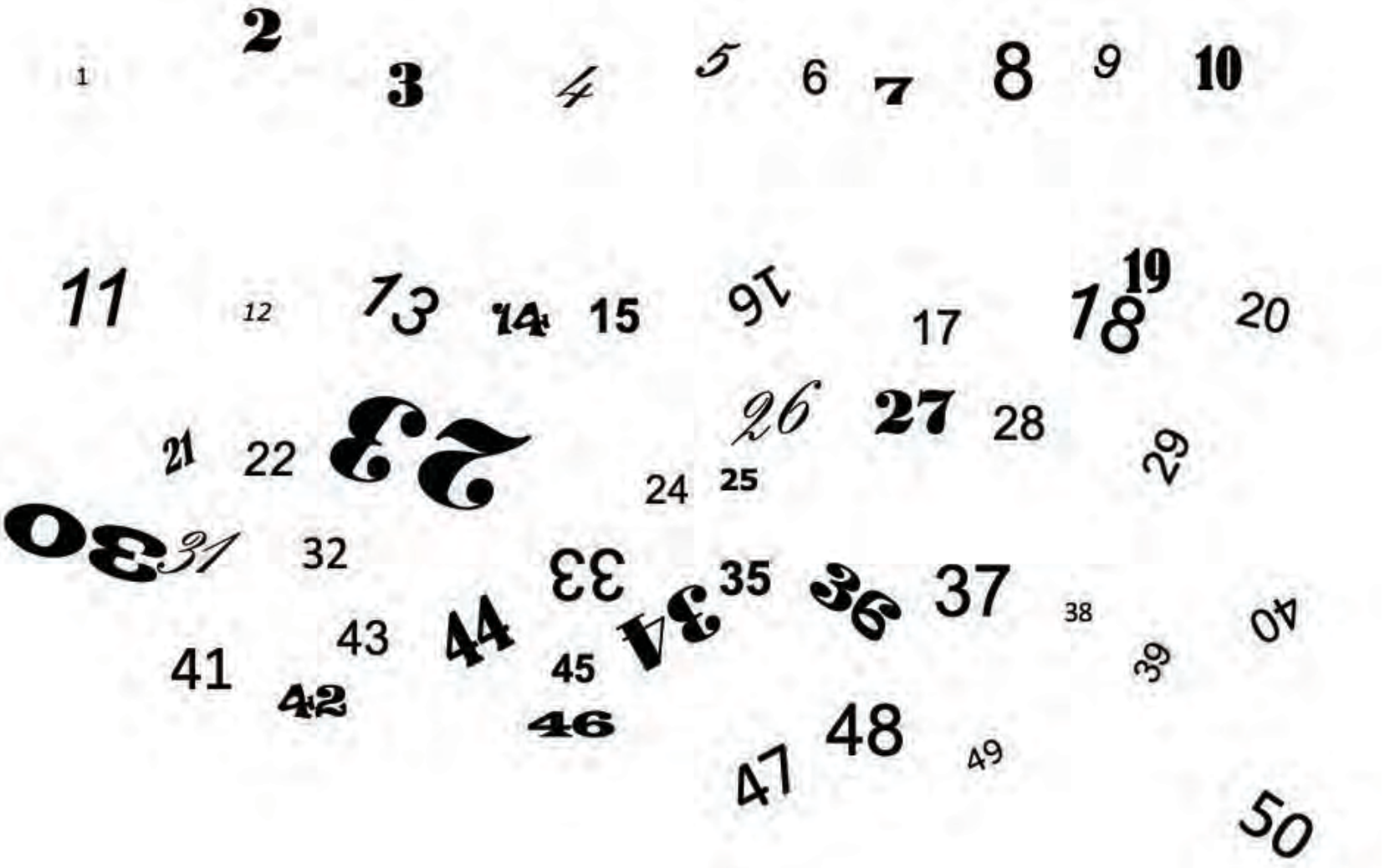
Round 1 - No Process



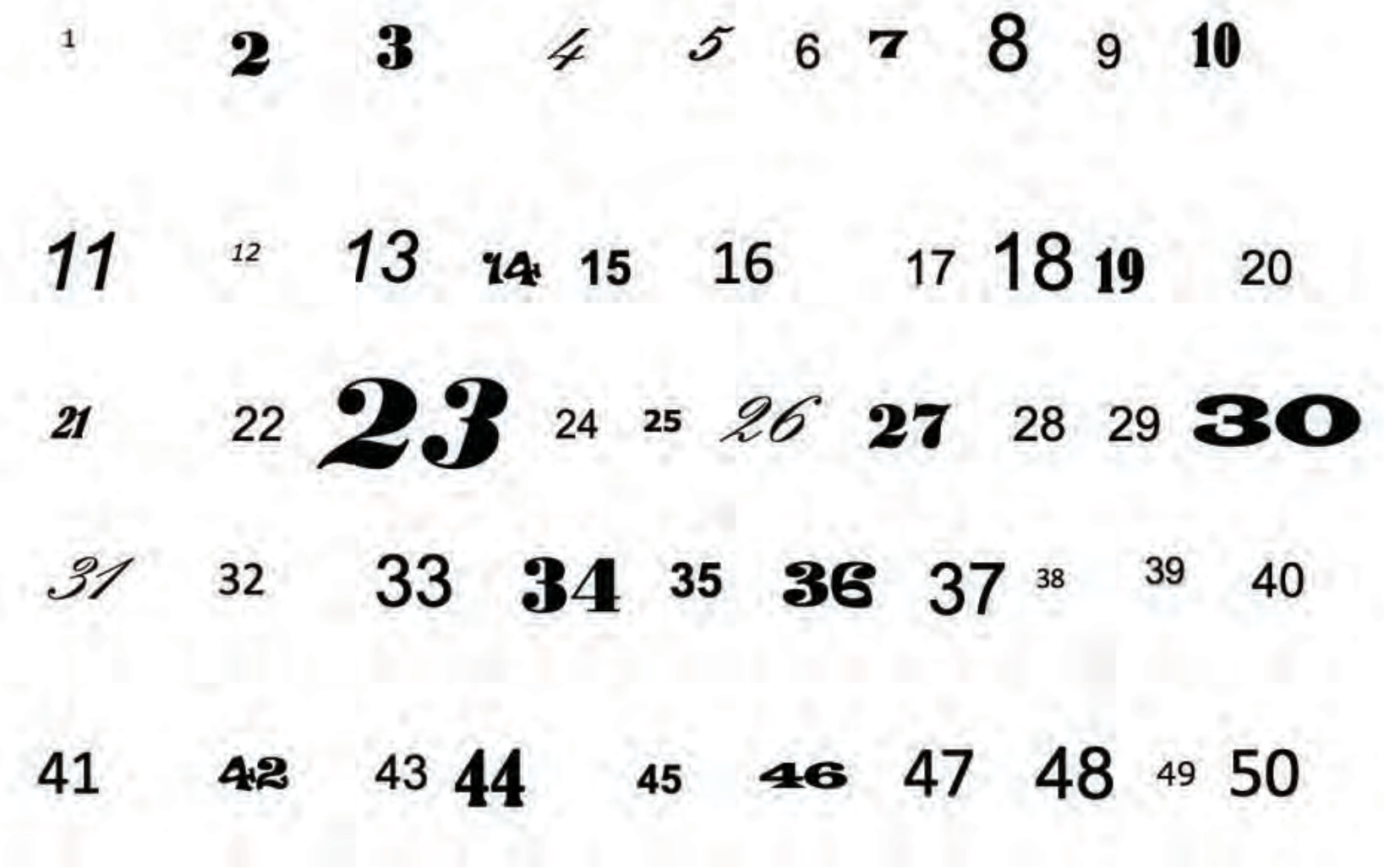
Round 2 - Sort



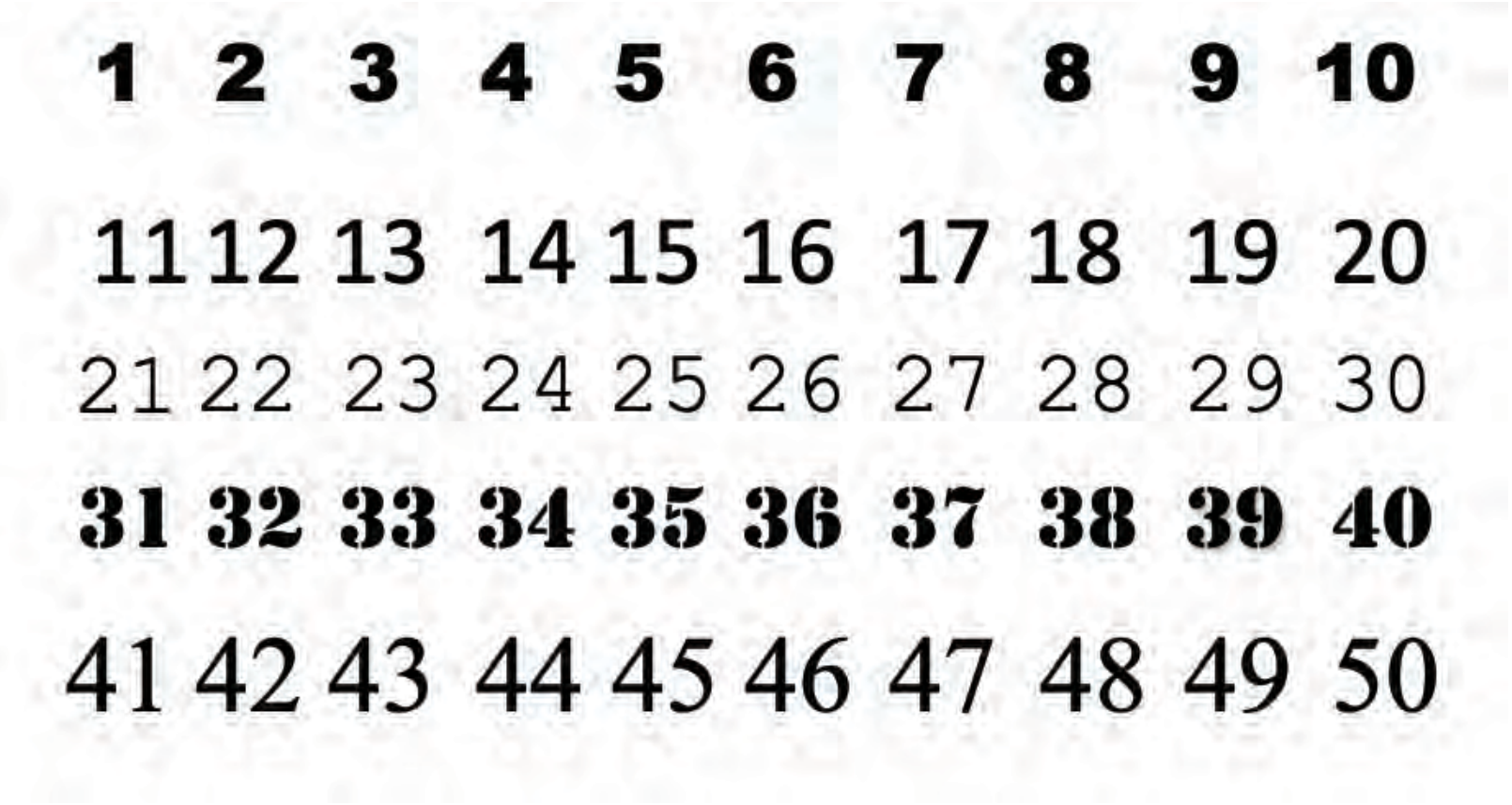
Round 3 - Set in Order



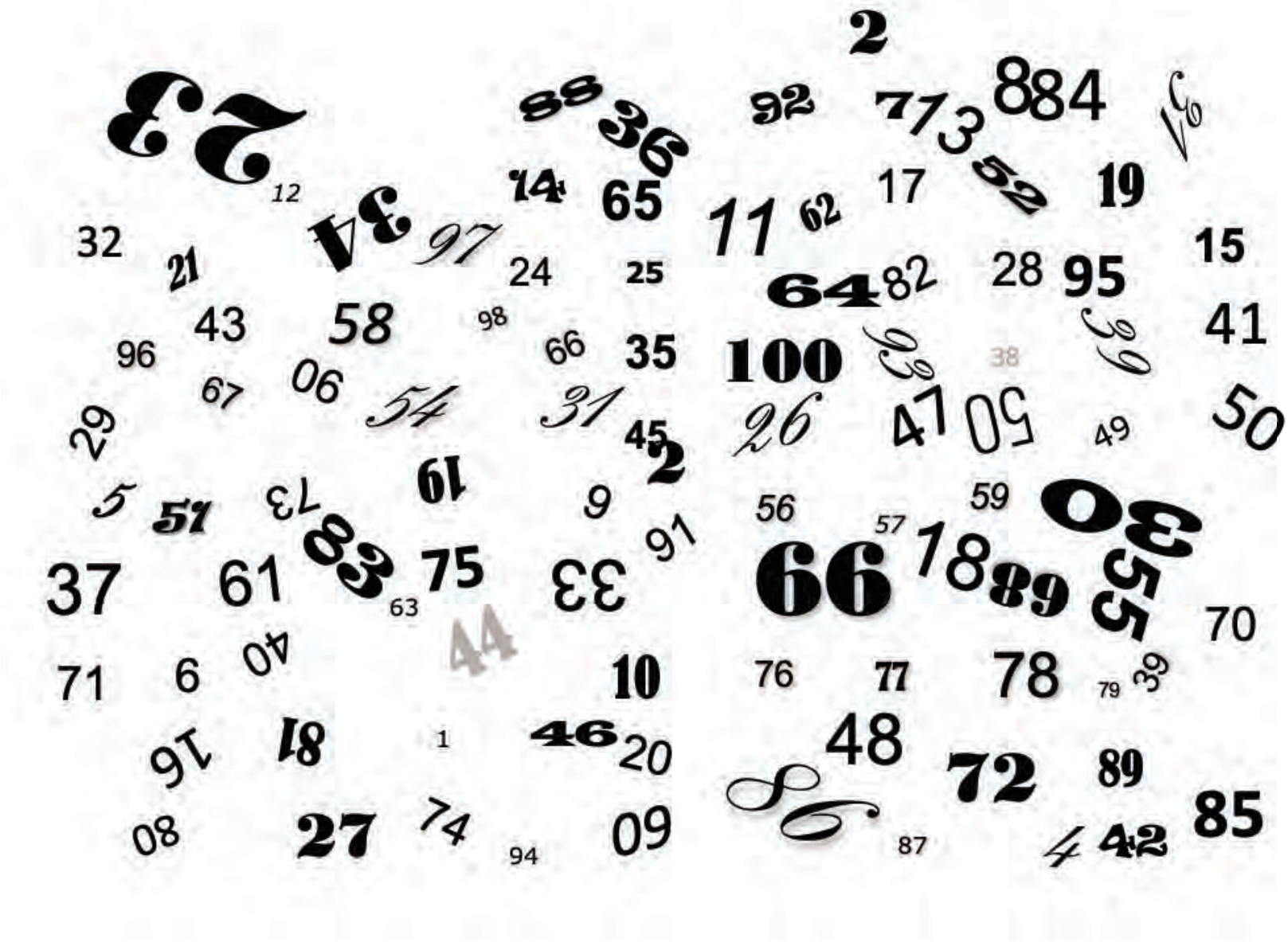
Round 4 - Shine



Round 5 - Standardize



Round 6 - Sustain



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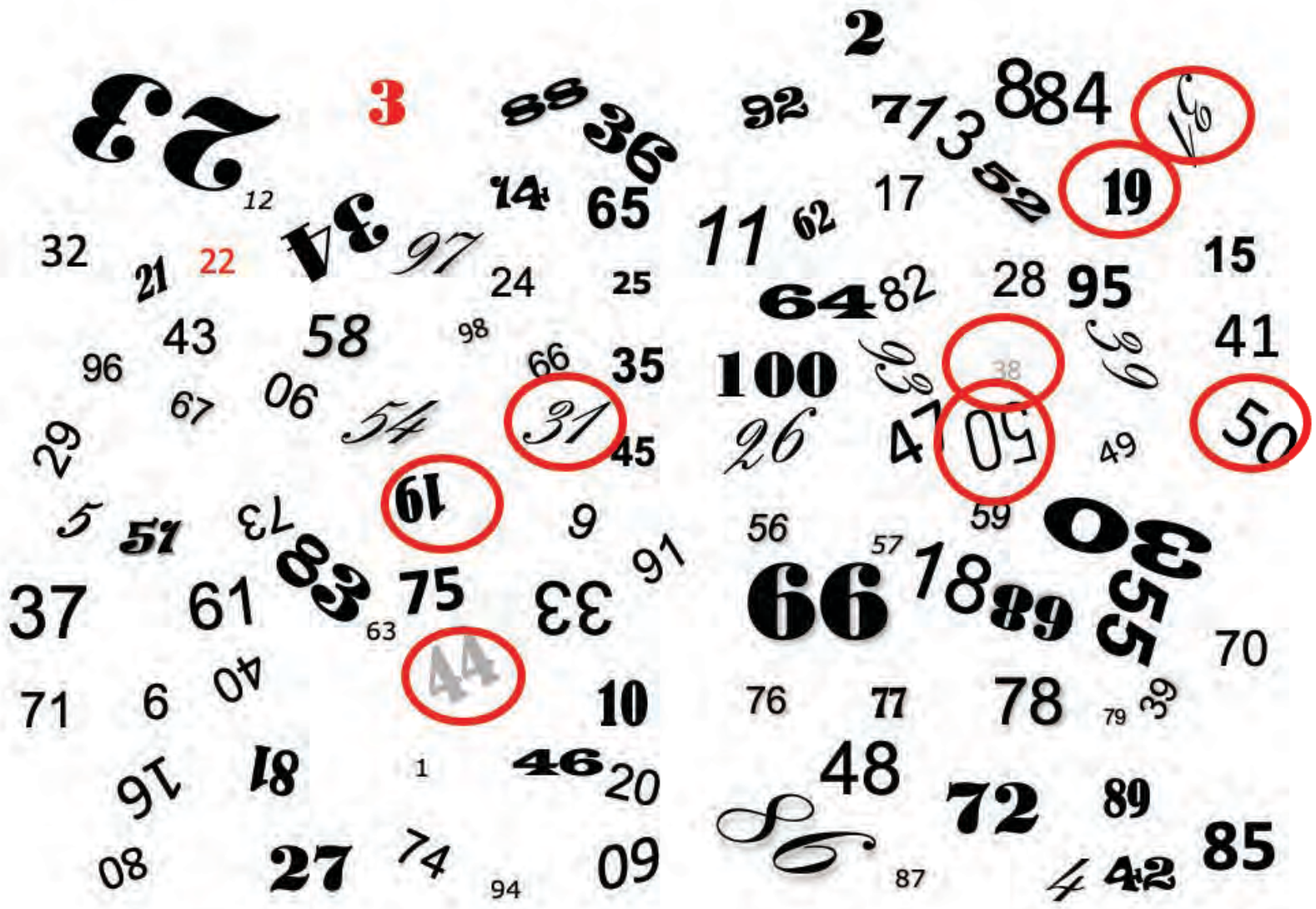

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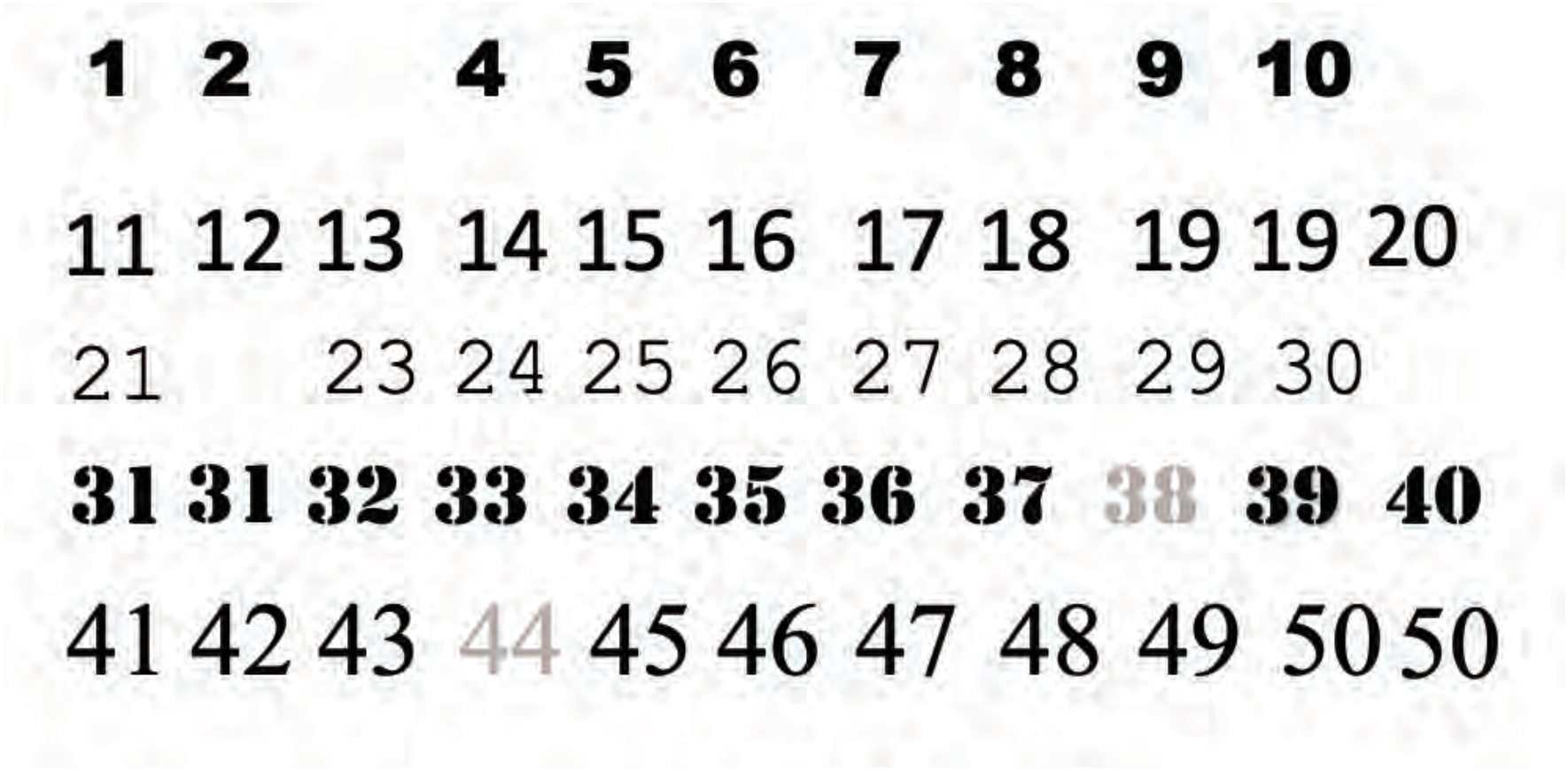

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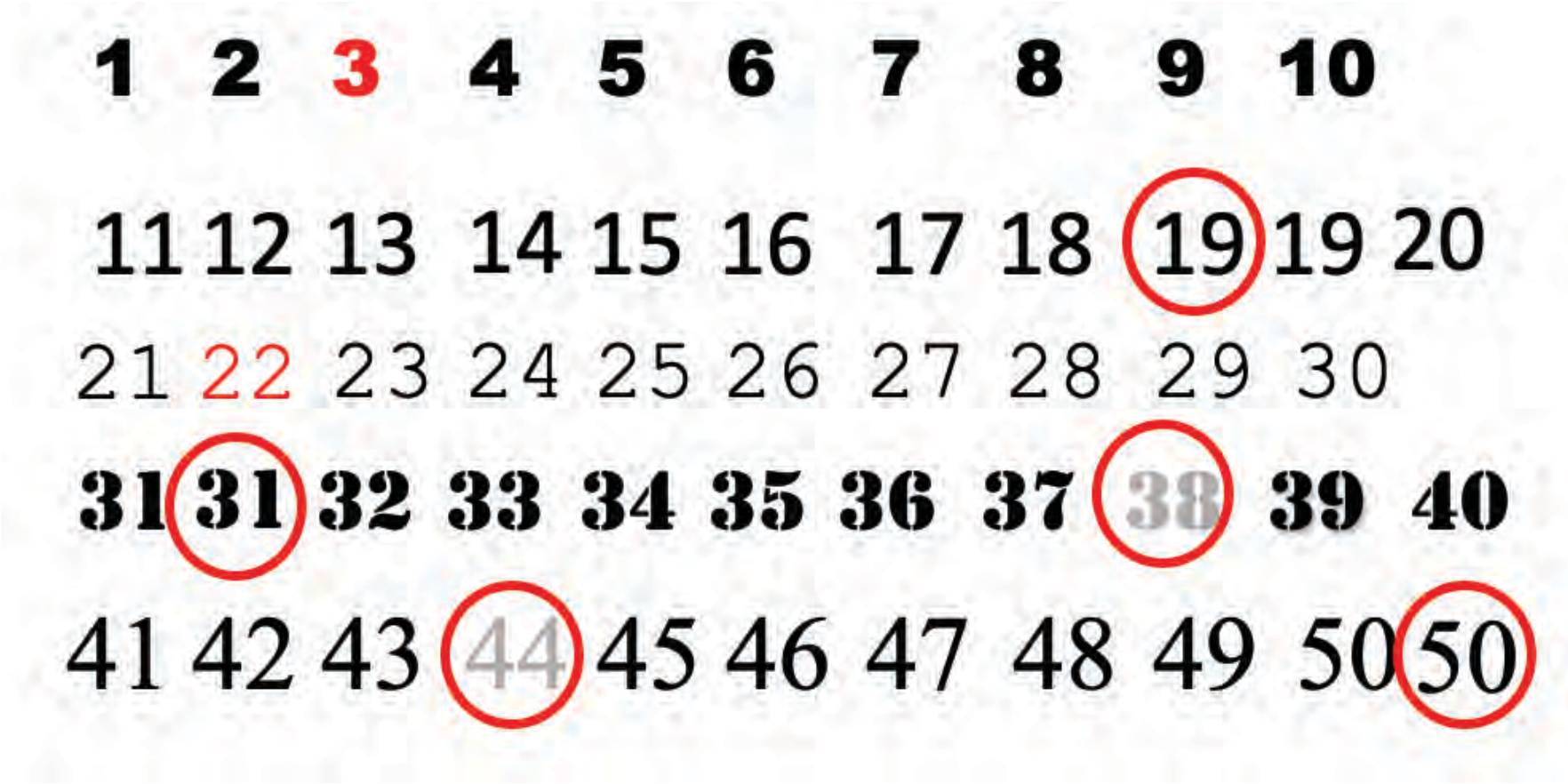

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IMAGE AND CONTENT CREDITS

Images

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Content

5S chart adapted from "5S Tutorial" (2021, May 22). Retrieved from https://asq.org/quality-resources/lean/five-s-tutorial
5S game adapted from "The 3 Best Lean Games" (2021, May 22). Retrieved from https://standrewslean.com/blog/the-3-best-lean-games-every-company-should-learn-to-play/

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