**BEAD EXPERIMENT RULES AND SEQUENCE**

Phase 1 “Multitasking” Rules and Experiment Sequence:

RULES:

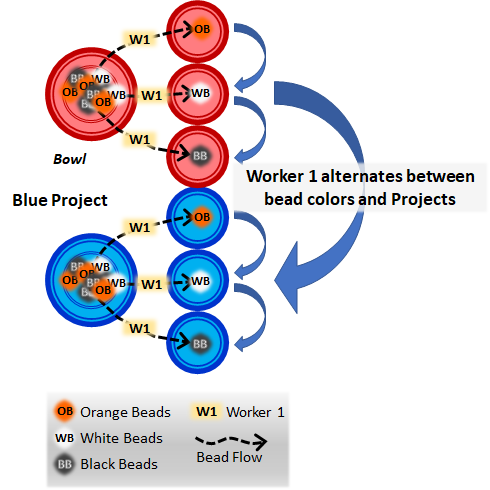
* Fingers may only be used to flip beads over (when called for), moving into groups (by sliding on the table when called for), or providing a backstop for scooping. During the experiment, beads may not be picked up or held.
* When scooping from the bowl to the plates (Worker 1), each scoop must consist of all of the same color. If more than one color is scooped, the contents of the spoon must go back in the bowl, and another attempt must be made (variation: fingers may be used to slide, not pick, undesired colors from the spoon back into the bowl)
* Workers 1, 2, and 3 will:
  + Work on both RED and BLUE projects per the experiment sequence
  + Follow the instructions of the RED and BLUE project managers
* The timekeeper will record the timing of the two projects, by either:
  + - Recording the start time and end time for each project (clock or watch)
    - Or recording the total time for each project (stopwatch or timer)
* When both RED and BLUE projects are active, each Worker will switch between each project after performing the current task (moving scoops of beads or flipping beads) 3 times on the same color bead, for the same project.
  + For example, Worker 1 will move 3 scoops of Orange beads for the RED project and then move 3 scoops of Orange beads on the BLUE project.
  + For example, Worker 1 will flip 3 white beads on the RED project, and then switch to scooping Orange beads to the plate for the BLUE project.
* Workers 2 and 3 cannot begin their tasks until all of the beads of the same color for the RED or BLUE project are on the appropriate plate.
* Worker 1 cannot start the final task until all of the beads of the same color for the RED or BLUE project are on the appropriate plate.



**Figure 1: Experiment Setup, Tasks, and Flows**

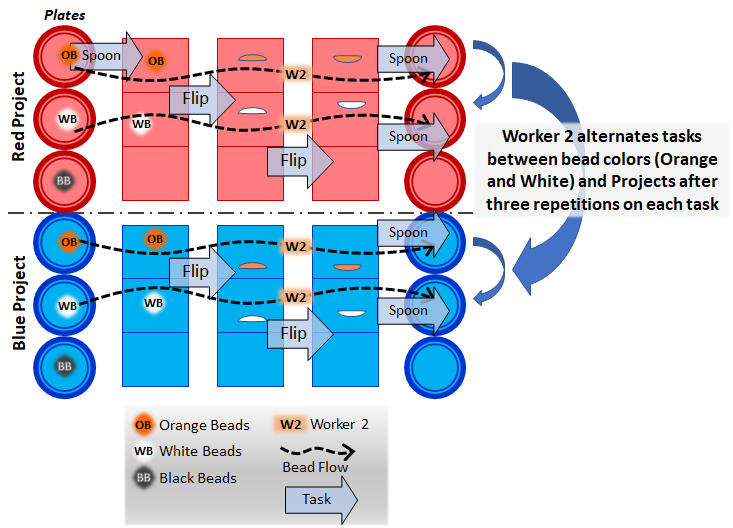
EXPERIMENT SEQUENCE (Refer to Figure 1):

1. Project managers have the bowl of beads, workers have spoons. Plates and bowls are on the table or experiment area. See Figure 1.
2. RED project starts first: project manager places the bowl full of beads on the table.
   1. Throughout the experiment, the RED project manager supervises the workers and ensures that they are performing their tasks and alternating correctly.
3. Timekeeper starts RED timer or records start time of RED project
4. Worker 1 starts moving beads from the bowl to the plates, alternating between the bead colors as follows:
   1. Place 3 scoops of orange beads on the plate for the orange beads
   2. Place 3 scoops of white beads on the white bead plate
   3. Place 3 scoops of black beads on the black bead plate
5. Timekeeper announces 10 seconds have elapsed
6. BLUE project will now start: project manager places the bowl full of beads on the table.
   1. Throughout the experiment, the BLUE project manager supervises the workers and ensures that they are performing their tasks and alternating correctly.
7. Timekeeper starts BLUE timer or records start time of BLUE project
8. Worker 1 finishes the current task on the RED project task and then begins alternating between the two projects and bead colors in the same sequence as Step 4 above. See Figure 2.



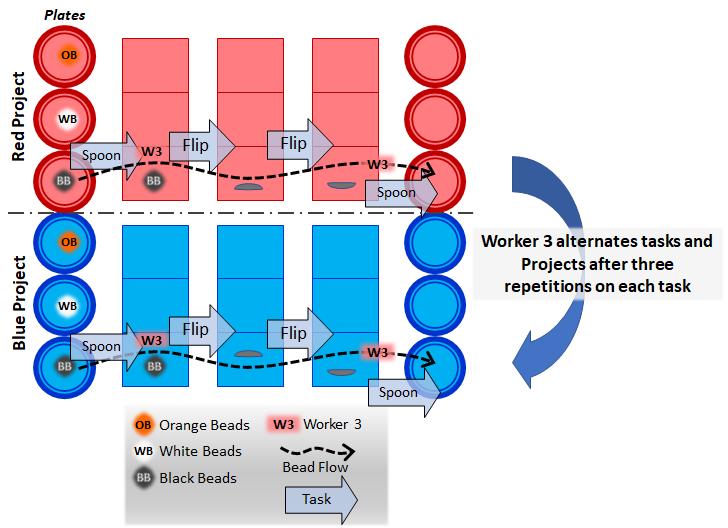
**Figure 2: Worker 1 Tasks - Multitasking**

1. When all Orange beads are on the correct plate, Worker 2 will begin scooping Orange beads, three scoops at a time, from the plate to the table sorting area. When all the White beads are the plate, Worker 2 will alternate between Orange and White Beads. If both RED and BLUE projects are active, Worker 2 will alternate between both projects (3 scoops of Orange beads for RED, 3 scoops of Orange beads for BLUE, 3 scoops of White beads for RED, 3 scoops of White beads for BLUE). See also Figure 3.
2. When all the Black beads are on the correct plate, Worker 3 will begin scooping Black beads from the plate to the table, three scoops at a time. If both RED and BLUE projects are active, Worker 3 will alternate between both projects (moving three scoops of RED project Black beads before moving 3 scoops of BLUE project black beads). See Figure 4.
3. Each project manager tries to keep Workers 2 and 3 focused on their projects (RED or BLUE)
4. When all the Orange or White beads have been moved to the table, Worker 2 will check 3 beads at a time. See also Figure 3.
   1. If any of the beads are round side (or lettered side) down, Worker 2 will flip the bead(s) to be round side (or lettered side) up, and move them to the center section of the project.
   2. If both Orange and White beads are all on the table, Worker 2 will alternate between Orange and White beads, 3 beads at a time.
   3. If both RED and BLUE projects are active, Worker 2 will switch between the two projects, always performing tasks in groups of 3 (3 “scoops”, 3 “check and flip”, alternating between bead colors and projects).



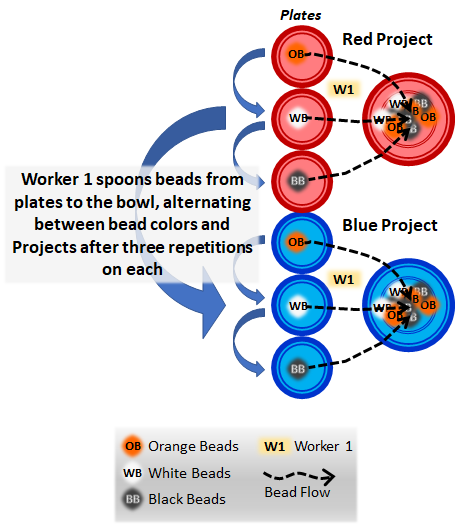
**Figure 3: Worker 2 Tasks - Multitasking**

1. When all the Black beads are on the table, Worker 3 will check 3 beads at a time.
   1. If any of the beads are round side (or lettered side) down, Worker 3 will flip the bead(s) to be round side (or lettered side) up. The three checked beads are slid to a group of “checked beads”
   2. If both RED and BLUE projects are active, Worker 3 will switch between the two projects, always performing tasks in groups of 3 (3 “scoops”, 3 “check and flip”, alternating between projects).
2. Each project manager tries to keep Workers 2 and 3 focused on their projects (RED or BLUE)
3. When all the Orange or White beads are round sides (or lettered side) up, Worker 2 will flip them to round side (or lettered side) down, 3 beads at a time before switching tasks. See also Figure 3.
   1. If both Orange and White beads are round side (or lettered side) up, Worker 2 will alternate flipping between Orange and White beads, 3 beads at a time.
   2. If both RED and BLUE projects are active, Worker 2 will switch between the two projects, always performing tasks in groups of 3 (3 “scoops”, 3 “check and flip”, 3 “flips” alternating between bead colors and projects).
   3. Worker 2 continues to flip, 3 beads at a time until all beads of each color are round side (or lettered side) down.
4. When all the Black beads are round side (or lettered side) up, Worker 3 will flip them to round side (or lettered side) down, 3 beads at a time before switching tasks
   1. If both RED and BLUE projects are active, Worker 3 will switch between the two projects, always performing tasks in groups of 3 (3 “scoops”, 3 “check and flip”, 3 “flips”).
   2. Worker 3 continues to flip, 3 beads at a time until all Black beads are round side (or lettered side) down.
5. Each project manager tries to keep Workers 2 and 3 focused on their projects (RED or BLUE)



**Figure 4: Worker 3 Tasks - Multitasking**

1. When all the Orange or White beads are round side (or lettered side) down, Worker 2 begins scooping the beads back onto the appropriate plates. Orange to Plate #1 and White to Plate #2.
   1. If both Orange and White beads are round side (or lettered side) down, Worker 2 will alternate scooping between Orange and White beads, 3 scoops of each color before alternating.
   2. If both RED and BLUE projects are active, Worker 2 will switch between the two projects, always performing tasks in groups of 3 (3 “scoops”, 3 “check and flip”, 3 “flips” alternating between bead colors and projects).
   3. Worker 2 continues to scoop beads to the plates until all beads of each colorsides each project are back on the plates.
2. When all the Black beads are round side (or lettered side) down, Worker 3 begins scooping the beads back onto Plate #3.
   1. If both RED and BLUE projects are active, Worker 3 will switch between the two projects, always performing tasks in groups of 3 (3 “scoops”, 3 “check and flip”, 3 “flips” alternating between projects).
   2. Worker 3 continues to scoop beads to the plates until all Black beads of each project are back on the plates.
3. Each project manager tries to keep Workers 2 and 3 focused on their projects (RED or BLUE)
4. When any color, for either project, is finished being moved back to the plates by Worker 2 and 3, Worker 1 begins scooping those beads into the bowls. See Figure 5.
   1. If more than a single plate has beads ready to be moved back to the respective bowl, Worker 1 will alternate between colors and projects, moving 3 scoops of beads before moving to the next color or project.
   2. Worker 1 will continue moving beads, alternating between 3 scoops for each color/project, until all beads are moved to the respective bowls.



**Figure 5: Worker 1 Finishing Task - Multitasking**

1. The timekeeper records the time that Worker 1 finishes moving beads for each project

OBSERVATIONS:

* There will be much noise, confusion, etc.
* It becomes clear that Worker 2 is the “bottleneck” (constraint).
* It is not uncommon for the blue project to finish before the red project!
* Normal range of completion times is about 6 minutes to 12 minutes PER PROJECT.
* ASK STUDENTS/PARTICIPANTS what COULD or SHOULD be done to improve the outcome. Some will suggest “practice”, or “process improvements.” Most will agree they MUST remove multi-tasking and delay the start (e.g. “choke the release”) of the second project if Workers are expected to participate on both.

Phase 2 “Non-Multitasking” Rules and Experiment Sequence:

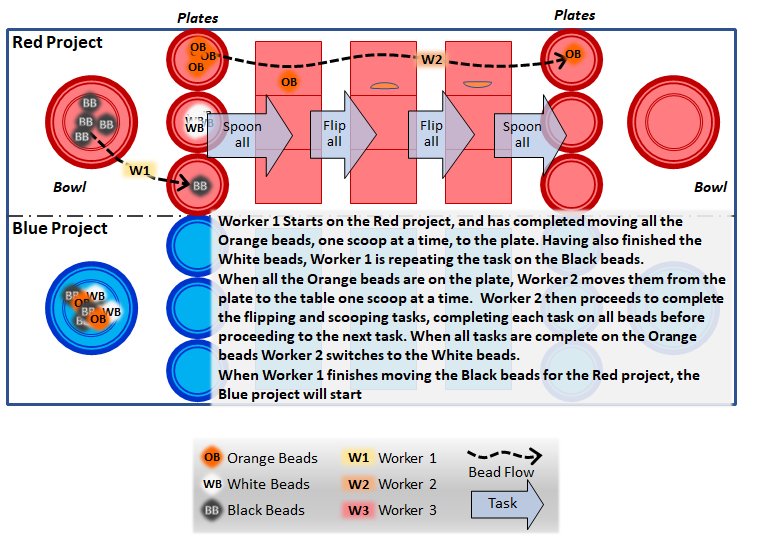
NOTE: Phase 2 should follow phase 1 at or prior to next scheduled class/period. Subsequent experiments with the same participants may switch the order (Phase 2 first) to demonstrate results will be similar regardless of order.

RULES FOR PHASE 2:

* See Phase 1 Rules

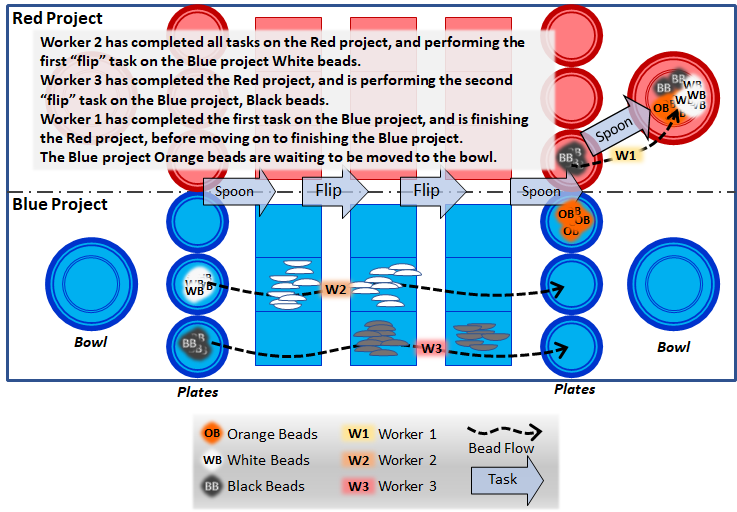
EXPERIMENT SEQUENCE:

1. Project managers have the bowl of beads, workers have spoons. Plates and bowls are on the table or experiment area. See Figure 1.
   1. The Project Managers are agreed that the RED project will flow first, and the BLUE project will start only when Worker 1 has completed moving beads to the plates for the RED project.
   2. The project managers should only need to remind each Worker what to do next or when to start
2. Timekeeper starts a timer or records start time (nearest second preferred) for each project
3. RED project starts first: RED project manager gives the bowl full of beads and three plates to Worker 1, and spoons to each Worker.
4. Worker 1 will move beads from the RED project bowl and put on the RED project plates in the following sequence (beads are moved with the spoon, one spoonful at a time):
   1. Place ALL the orange beads on plate #1 and then
   2. Place ALL the white beads on plate #2 and then
   3. Place ALL the black beads on plate #3



**Figure 6: Worker 1 and Work 2 Start the Red Project Tasks - Non-Multitasking**

1. When Worker 1 has finished moving the Black beads, the BLUE project manager provides the bowl of BLUE project beads to Worker 1, who then repeats Step 4 on the BLUE project beads.
2. When all RED project Orange beads are on plate #1, Worker 2 will:
   1. scoop ALL the Orange beads, 1 spoonful at a time, from the plate to the table sorting area.
   2. Check that ALL the Orange beads are round side (or lettered side) up, flip any beads that are not round side (or lettered side) up.
   3. Flip ALL the Orange beads to be round side (or lettered side) down
   4. Scoop ALL the Orange beads, 1 spoonful at a time, from the table back to plate #1.
3. Worker 2 repeats Step 6 for the RED project White beads, and again for the BLUE project Orange and White beads.
4. Worker 3 performs Step 6 for the RED project Black beads and again for the BLUE project Black beads.
5. When all the RED project Orange beads are returned to Plate #1 by Worker 2, Worker 1 will:
   1. Move all the Orange beads, 1 spoonful at a time, from the plate #1 to the RED bowl.
   2. Repeat step 9.a. for the RED project White beads, and then the RED project Black beads.
   3. Repeat steps 9.a. and 9.b. for the BLUE project beads in the same order..



**Figure 7: Worker 1 finishing the Red project, and Workers 2 and 3 performing tasks on the Blue project - Non-Multitasking**

1. The timekeeper records the time that Worker 1 finishes moving beads for each project. These should be different numbers.

OBSERVATIONS:

* There will be much less noise and confusion.
* All participants (especially Worker 2) are much happier.
* Completion times for EACH project tend to be 1:45-2:30 minutes each.
* Some students will argue there’s a learning effect. [This is minimal – You can run the simulation with a “control group” doing original process again with limited improvement. Or, run a control group without multi-tasking for their first trial and get almost identical results.]
* THE POINT? Scheduling projects by removing multi-tasking AND “choking the release” (delaying the start) of subsequent project work based upon the load on the “bottleneck” Worker is VITAL to managing projects correctly
* This is the part of the behavioral shift injections in the Theory of Constraints (TOC)-based method of project management called “critical chain”.

How did it work? Magic?

* For both phase 1 and phase 2 of the experiment, each bead had the same things happen to it.
* Each Worker performed identical tasks, an identical number of times, in both Phase 1 and Phase 2.
* Multi-Tasking projects attempts to achieve efficient use of Workers and maximize incremental progress equally amongst all projects.
* Multi-Taking prevents the efficient flow of projects.
* Multiple projects can overlap at the “team” level, but not at the Worker level. In Phase 2 of the experiment, the “team” could be considered to be “multitasking”, because the entire team has more than one project being worked at one time. The difference is that it stops at the team level, leaving each Worker free to concentrate on completing all the work on a single effort
  + Worker 2 was delayed starting work during multitasking, because they had to wait until Worker 1 finished most of the entire sort operation before ALL of a single color was separated. Eliminating the multitasking ensured that Worker 2 (the bottleneck) would start when Worker 1 completed a much smaller fraction of their total work on the two projects.
  + Worker 1 was delayed in performing the integration step, because they had to wait for Workers 2 to finish a single color, while dividing attention between 12 different tasks (2 projects, 2 colors, 3 operations).