Running "The Beer Game" for Large Classes

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Running "The Beer Game" for Large Classes

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Abstract
The Beer Distribution Game is a multi-stage supply chain simulation played in groups of four in many undergraduate and graduate business programs. The simulation is renowned for not only the valuable learning experience the manual game provides, but also the many challenges faced by faculty in administering the game. While others have implemented computer based versions of the simulation to ease the administrative burden, this paper describes our lessons learned in administering the manual game for 400 students (100 simultaneous games). After reviewing the literature on administering the simulation, we describe our approach, including how complete board sets were created cost effectively and how operating costs were kept low, how game boards can be setup quickly, and how we increased the effectiveness of the game playing instructions. We then provide evidence of the teaching effectiveness, and discuss future improvements. By implementing these techniques, instructors have been able to provide students with the optimal hands-on learning experience of the game without burdening themselves with excessive administration.

Background
The Beer Distribution Game, introduced in the 1960's at MIT's Sloan School of Management and further popularized by Sterman (1989, 1992), is a systems dynamics simulation. The exercise consists of a multi-stage supply chain simulation where participants try to meet customer demand while minimizing holding and stockout costs. A debrief session typically follows where results are compared and lessons learned are discussed. Played in many undergraduate and graduate business programs, the beer game is renowned for both the valuable learning experience the manual game provides, and the many challenges faced by faculty in administering the game (Coakley et al., 1998, Jacobs, 2000, Chen & Samroengraja, 2000).

Correspondingly, electronic versions of the game are becoming more popular, including both networked computer lab (Coakley et al., 1998) and internet based (Jacobs, 2000) simulations. Although computer based simulations are easier to administer, they do not provide students the opportunity to learn with all senses and experience realistic human interactions while dealing with physical products (Ammar & Wright, 1999). This paper describes lessons learned after administering the manual Beer Distribution Game (beer game) to groups of approximately 400 undergraduate students each term over the previous three years. We have been able to significantly reduce both the cost and challenges of administering the manual game, while further enhancing the "hands-on" learning experience. In addition to overwhelmingly positive student feedback, we have experienced a significant increase in the "I learned a lot" end of course evaluation measure when, other than including the beer game, no other significant curriculum changes were made in the course.

Overview of Approach
The beer game was historically used as a key component of our undergraduate "inventory and supply chain management" senior elective course only. This resulted in only 40 or so students of the 500-700 students in each year of the program experiencing the beer game. After receiving feedback from those participating students that all students in the program should have the opportunity to experience this simulation, we began investigating the most effective way to "scale up" running the game from 40 to 400 concurrent students, which would enable the inclusion of the beer game in our fundamentals of operations management course that is required for our undergraduates.

Although intrigued by the many potential benefits of computer based simulators for administering the beer game (Coakley et al., 1998, Chen & Samroengraja, 2000), the limitations of finding a computer lab for 400 students, combined with the potential risk of technical problems occurring during the game, led us to choose the manual approach. Limited funding further required a more frugal approach. Through various techniques (detailed below), we have achieved a cost per board set of approximately $20 (all costs are in Canadian Dollars), far below the $105 USD per board set quoted by MIT's System Dynamics Society ("Production Distribution Game", 2008) the primary beer game supply organization.

Our beer game is administered in the evening (regular daytime scheduled lecture durations are only 75 minutes) at a rented facility on campus. It is played in groups of four students, as compared to 8 (4 pairs) described in Sterman (1989), providing each student with the full learning experience. This results in approximately 100 simultaneous games. To encourage attendance, participating students receive 2% of the course grade, while students who choose not to attend (excluding those with conflicts such as another regularly scheduled class session) receive zero on this course component. The debrief session is conducted back in the regularly scheduled lecture, which occurs within 48 hours of playing the game (see "The Debrief Session" section for details).

Although the game can be conducted with the instructor leading students through each step of each round (Jacobs, 2000), we allow the groups to play at their own pace after guiding them through the first two rounds, which is similar to Coakley et al.'s (1998) approach. Also, we do not inform participants ahead of time that we will be playing "the beer game" as we have found that some may search the Internet and in seconds get the "secrets" of the game on their screen. To minimize this "spoiler" risk, we simply refer to it as the "Supply Chain Management Exercise" in the course outline and schedule.

Details of Approach
Costs for administering the beer game can be broken down into one-time (fixed) costs (ex. game boards) and recurring (variable) costs (ex. order slips) that occur each time the game is administered. Table 1a provides details of fixed costs while Table 1b provides the recurring variable costs. As can be seen, our fixed cost per board set is under $18 while our recurring costs for 400 students is approximately $1,300, equating to only $3.30 per player.

One-time (Fixed) Costs
For one-time costs, the game boards comprise the majority of the expense. While MIT's System Dynamics Society sells 8 player (4 pairs) 30" x 100" vinyl game boards for $85 USD each ("Production Distribution Game", 2008), we worked with our university's printing services department to design and produce 4 player 26" x 40" Coroplast colored game boards for a cost of $14.50 each. The professional graphic design created an appearance of a real board game (Exhibit 1), while the Coroplast is light and durable, enabling repeated use and easy storage. In designing the game boards, we chose to reverse the positions as presented in Sterman (1989, 1992) to match the typical left-to-right flow that students are accustomed to. In researching

alternatives for playing pieces (each playing piece represents a case of beer during the game), nothing could match the durability and cost of simply using pennies. We are still using our original 400 rolls ($200 worth) of pennies years later. (Note that your local bank branch may require a few days notice to obtain such a supply; on the lighter side, you will likely get many strange looks when picking up your order at the bank, and explaining how coins qualify as an expense to your accounting department may also prove entertaining.) We have found two plastic beer cups (which can be obtained from your local grocery store) work great for storing the materials for each game (Exhibit 2) and they also provide mini garbage and recycling containers for players during the game. Our campus printing services also created demand card sets from thick paper stock, which include a "stop" card to communicate to students when their game has finished (see "Logistics – Finishing the Games" section for further details). If required, alternative demand scenarios can be incorporated into the game by simply printing different retail demand values on a separate set of these re-usable customer demand cards.

Recurring (Variable) Costs
For each board set, three 1½ inch square notepads of 50 sheets each, whose color corresponds to the relevant player position (Retailer, Wholesaler, Distributor) are required (the Factory position pulls raw material into production and does not require an order notepad). In addition, each board set requires four copies (one per position) of an order tracking sheet showing 50 "rounds", and two full page graph templates (inventory level, order quantity). Ideally, your institution may have a rent-free facility to accommodate a large group (including audio-visual requirements of large screens and a sound system for communicating instructions), however we incur a cost of $500 for this service. Teaching assistants are paid $50 for approximately three hours of labor (setup, helping teams, administration, and cleanup), and they have usually played the game themselves within the last 6-12 months.

Despite recommendations to provide a 4:1 groups to teaching assistant ratio for manual games (Ammar & Wright, 1999), we have found that our animated instructions and other approaches described below have enabled us to successfully use a higher 10:1 ratio, and we are contemplating increasing this ratio even further. Even computer based beer game simulations, which include automated steps for participants, require teaching assistants for effective administration. Coakley et al. (1998) used one instructor and one lab assistant for up to 15 teams, for a ratio of 7½:1. Our ability to employ a higher ratio (10:1), even when using a manual approach, appears to indicate that our techniques are highly effective in communicating how to play the game.

Logistics - Setup:
Prior to "game day"
Approximately one week prior to the beer game event, we e-mail all registered students a reminder of the event in a W5 (who, what, when, where, why) bullet format. We also handout a paper currency sized reminder printed on colored paper that includes the W5 bullet content and a map to the facility. For audio visual, we typically have two large screens (ideally elevated so people at the back can see the entire screen) connected to a single laptop and a cordless microphone for the purpose of communicating game instructions.

Based on past challenges relating to students understanding how to properly account for negative inventory (backlog) during the game, we now include a one-slide example of this logic in the final class prior to the game (Exhibit 3). The example is based on a retailer having exclusive rights to sell a product and is covered during our inventory management topic in the course. Including this two minute example in our lecture notes has significantly reduced the frequency of negative inventory problems during the subsequent beer game. This has also been the primary factor behind reducing the number of teaching assistants required. We also

have a policy of groups of four for all course related group work, and inform students that they are to play the game with their assigned group mates.

Finally, to facilitate quick setup at the facility, we pre-assemble "kits" for each game board (Exhibit 2) that includes pennies, demand cards, colored order pads, and two order forms for each position with initial demand already written on them. This enables a complete game board to be setup in approximately one minute.

Just prior to starting
Prior to allowing students into the facility, our team of 10 teaching assistants distribute the game boards and pre-assembled kits, and then get each game board setup in the starting condition (Exhibit 1). This typically takes approximately 15-20 minutes for 100 game boards. Once the doors open, students are reminded to find their group and sit at any game board. Originally we had assigned seating, however we found this cumbersome to administer and now let them find their groups themselves. Even with 400 students, thanks to text messaging / cell phones, it only takes about five minutes to have them seated in their groups. Once the official start time is reached, we ask all incomplete groups (less than four) to stand up and then we have our teaching assistants re-assign students into groups of four. We have also learned to reserve a few game boards near the entrance for a "late arrivals section" to minimize the risk of disruption during the instructions. Finally, we announce that the person seated in the Retailer position will act as a player / coach during the game. Since the instructor does not guide the groups through the entire simulation, it is critical that one player per group take the lead in ensuring everyone is synchronized when executing each step, each round (we have found that having players out of sync is the primary cause of confusion). In the past, we let the groups decide who would be responsible for coordinating that all group members were on the same round and step, with mixed results. Due to the customer demand pattern, we have found the retailer has the most "spare time" during the simulation, and correspondingly have assigned the coordination responsibility to that position. We announce the coaching responsibilities of the Retailer and suggest quickly changing positions if the Retailer is not comfortable shouting instructions to the team.

Logistics - Playing:
Prior to explaining the details of the game, we first show an agenda and remind them of two main reasons why they should pay close attention to the instructions: only the first two rounds will be guided, and to finish in under 90 minutes, they need to adhere to the instructions. Via PowerPoint slides, we then introduce the game board structure and the goal of the game, "minimize your inventory costs by managing your 'Current Inventory' box." Different from Sterman (1992), we do not announce or provide prizes for the winning team. We have found that in such a large group, this creates an incentive to ignore the game rules (e.g. not to verbally discuss order quantities) and to coordinate efforts to "win", thereby subverting the intended learning experience. Perhaps in smaller groups this behavior can be monitored by the instructor; however this close observation is not feasible with 100 games occurring simultaneously.

Within minutes we are then into the step-by-step instructions. Although we originally considered making a video of how to play the game, we found PowerPoint's "custom animation → custom path" feature could show exactly how to move the playing pieces, record values on the tracking sheet, and place orders on the game board. Despite being intimidated by the thought of animating in PowerPoint, within hours we had the animation completed. An example in provided in Exhibit 4. For our first large group attempt, we thought it would be best to "zoom in" and animate how one player (e.g. wholesaler) would play. Unfortunately, we found the other three positions were not following along as expected, as they thought the instructions applied only to the Wholesaler position. Correspondingly, we now animate the entire game board simultaneously (all

positions moving their pennies, all positions placing orders). After watching one complete "round" of step-by-step instructions, the animated instructions are repeated twice providing participants with two rounds of "guided" instructions. Following this (approximately 20 minutes), the steps are listed on the screen and the Retailers are instructed to coordinate their teams through the remainder of the game.

The teaching assistants then constantly roam the room in case of questions, and they are instructed to interrupt (rather than wait for a player to raise their hand) if they notice confusion or inaccurate play. Most issues subside within 20 minutes as participants learn how to play. This does not mean everything works perfectly. We find a handful of groups will have one confused player because their inventory (pennies) does not correspond with their tracking sheet. Rather than conducting a detailed investigation of the problem source, we instruct the teaching assistants to adjust the tracking sheet's ending inventory value to match their physical count of pennies in their "current inventory" box. Although this creates a relatively minor data error for that individual, it enables the group to proceed with the game rather than becoming increasingly frustrated with that player, and to not "miss the forest for the trees".

Approximately one hour after the start, we have a handful of teaching assistants hand out mini chocolate bars to the participants. We have found this minor expense is well worth the resulting stress relief, "sugar fix", and goodwill towards the game for the students. Only once did we neglect to provide these snacks and everyone seemed more frustrated and tired than normal, including the teaching assistants. Finally, during the first hour or so, we walk around with a digital camera taking pictures of game boards at various stages for eventual use in the debrief session. We try not to include participant faces in these pictures as it provides anonymity for those who are embarrassed by their performance. We have also found that this approach enables us to re-use photos for future term debrief sessions as game boards often tend to have similar appearances.

Logistics – Finishing the Games:

Consistent with Sterman (1989), our games cease after 36 rounds to eliminate horizon effects, despite the game instructions stating that 50 rounds should be played. To ensure all groups (who are progressing at their own pace) are communicated this unexpected stoppage consistently, we insert a "stop card" as the 37th customer demand card. With 100 simultaneous games occurring at varying paces, we found it infeasible to expect the teaching assistants to monitor and subsequently verbally instruct every group to stop after completing round 36. The "stop card" instructs the group to raise their hands, at which point a teaching assistant will arrive to confirm their game is complete, and provide a summary template "cover page" for the group to attach to their submitted graphs and tracking sheets. This template requires participants to fill in their names for attendance tracking purposes and their individual inventory costs for comparison purposes during the debrief session. In addition, the template asks the group to describe their feelings playing the game and who/what was the main reason for their supply chain's success/failure. These responses provide entertaining comments which are then combined with the photos taken during the evening into a brief PowerPoint slide show that starts the debrief session.

Also similar to Sterman (1989), we have found the majority of groups complete the game and the required paperwork (cost calculations, graphs, cover page template) within 90-120 minutes. Although the computer based simulators include automated graphing to save time (Jacobs, 2000), we have found the five minutes required of each individual to manually graph their own data reinforces the learning from the game (while frequently providing comic relief to the participants as well). With their completed paperwork in hand, the group is directed to our administration table located at the exit, which is staffed by four teaching assistants. Two teaching assistants record attendance from the names entered on the cover page template onto the class list, while the other two separate and tape groups graphs together in a top-bottom order (Factory, Distributor,

Wholesaler, Retailer) and place them into folders. The graphs are then taped onto the classroom wall during the debrief session so that their results can be easily compared to those presented in Sterman (1989). The remaining teaching assistants are responsible for organizing and packaging the reusable game supplies (game boards, demand cards, and pennies), enabling all administrators to leave within minutes of the last group's paperwork submission.

The Debrief Session

We have chosen to conduct the debrief session back in the regularly scheduled lecture which occurs within 48 hours of playing the game since permitting the groups to play at their own pace results in staggered completions (up to an hour range). This approach also provides the opportunity to prepare a more thorough and specific review of what happened via the pictures, comments, and graphs. We start the session with a "pictures and comments" PowerPoint presentation that combines the most entertaining and honest comments from the template cover page submissions with various game board photos taken during the exercise in a time-lapsed approach that provides an entertaining illustration of the bullwhip effect occurring to the supply chain. Next, we show the average results by position from the MIT students and the selected graphs as presented in Sterman (1989) for benchmarking purposes. We have found that this allows the students to put their perceived poor performance in context and embrace the debrief session. Our debrief session then provides lessons learned by proceeding through diagnosing why the problems occurred in the game, how they could have been solved in the game, and how they can be addressed in the real world. Finally, we show the video from the MacNeil/Lehrer News Hour (1989) in which a reporter participates in a beer game session conducted by MIT's John Sterman (the video can be purchased from MIT's System Dynamic Society for $25 USD). Concerns that the video might be "dated" were alleviated by overwhelmingly positive student feedback to keep showing the video in future debrief sessions and realizing the validity of the reporter's extrapolation of the beer game lessons to today's business environment.

Evidence of Teaching Effectiveness

We have continuously assessed the teaching effectiveness of our approach to administering the beer game in various ways. Student feedback forms, increased attendance, and university conducted teaching evaluations have all indicated continuous success.

The cover page template that participating groups are required to submit has included a question on how we could better administer the game. The frequency of suggestions has drastically reduced as we have gradually incorporated the procedures described in this paper. Recently, we added the question "do you think the learning experience would be better if the game was played electronically?" and despite surveying the young "electronic generation" of undergraduate students, over 70% of participants have responded "no", stating that the physical learning and social interaction was key.

Given that we only provide 2% of students' final mark for attending this out of lecture evening event, some non-attendance was expected. From an initial year high of just over 8.0% absent, we are now experiencing only 1.5% non attendance. We speculate that this significant improvement relates to former students recommending current students to attend the event. Hopefully this is an indication of the educational value and the overall experience of how we conduct the simulation.

Our university conducts student course evaluations which include twelve measures scored on a seven point Likert scale (with endpoints 1=unacceptable, 7=excellent). To evaluate our effectiveness in administering the beer game to such a large group, we compared the results from the "I learned a lot in this course" item before and after the game was incorporated into the course. No significant changes to course content

occurred other than incorporating the beer game, and the analysis below includes only courses taught by one single instructor. Our analysis of the "I learned a lot in this course" item compared 14 course sections representing 508 students prior to the inclusion of the game with 13 course sections representing 305 students after the inclusion of the game. An ANOVA comparison of means between the two groups provided an average of 6.08 for the first group and 6.31 for the second group. Even for such a small sample size, the F-statistics is significant ($p = 0.017$). To further investigate our effectiveness in scaling up the beer game simulation from the 40 students in our senior elective course (in which the beer game was originally a key component) to the 400 students in our required core undergraduate course, we compared the "I learned a lot in this course" item between the two sets of courses. Similar to our above analysis, we compared only the results for the instructor who facilitated the beer game in both courses. The average score from the last time the elective course (40 students) included the beer game was 6.27 which is not significantly different from the 6.31 average score for the undergraduate core required course (400 students). This further provides another indication that our techniques to scale up the delivery of the beer game simulation from 40 to 400 students has been successful.

Anecdotally, we have observed the learning from the game in subsequent lectures. Prior to introducing the game, students had difficulty grasping supply chain managements concepts such as the value in working closely with suppliers, that demand and supply uncertainty require safety stock, and the value in obtaining end consumer demand by employing vendor managed inventory. After playing the game, students inherently understand how valuable these concepts can be for effective supply chain management, which in turn has resulted in a more efficient and interactive lecture environment. In addition, following the first year the beer game was introduced into the required core undergraduate course, the instructor described above received their first two teaching awards, one from the University's Students Union organization and the other from administrators.

Future Improvements
Despite our successes to date, there are a few aspects we hope to improve to further reduce remaining administration challenges. First, the reorganizing and resorting of the customer demand cards per group (four 4's, thirty-two 8's, one stop card, and fourteen 8's), and preparing the "preset" order forms (that are required for the starting condition) for next term's game requires much manual labor. We plan to investigate the feasibility of having the team of 10 teaching assistants complete this immediately after the conclusion of the game, or alternatively, treating these as a recurring expense and simply reordering them from printing services each term. Secondly, we plan to tell participants to "bring spare change" to the event (add to reminders described above), as some participants have found that using dimes and quarters aids in managing their inventory of pennies. Finally, we plan to schedule a "refresher" session for the teaching assistant team within 24 hours prior to event as we periodically have received feedback that some should be better prepared to assist the more challenged groups.

Conclusion
In this paper we have described and detailed various techniques that have enabled us to effectively administer the beer game to groups of 400 students (100 simultaneous games). By incorporating the approaches described in this paper, students can obtain the maximum learning experience from the beer game with minimal administrative challenges for faculty and minimal costs for administrators.

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Tables

Table 1a: Fixed Costs (per board set)

Description	Details	Cost Type	Cost per group
Playing boards	26" X 40" coroplast (5 colors)	One-Time	$14.50
Storage containers for materials	2 plastic beer cups	One-Time	$0.08
Playing pieces - pennies	4 rolls @ $0.50 each	One-Time	$2.00
Demand cards – 2 sided	4 4s, 46 8s, 1 "stop" card	One-Time	$1.40
			$17.98

Table 1b: Recurring Variable Costs (for 400 students or 100 games)

Description	Details	Quantity	Unit Cost	Total Cost
Facility Rental	Flat room, Table, Chair, and AV Setup	1	$500.00	$500.00
Teaching Assistants	$50 each for 3 hours	10	$50.00	$500.00
Order slips – colored notepads	3 colored pads of 50 sheets each	100	$2.05	$205.00
Tracking sheets & graphs	4 pages @ $.04 each X 4 players	100	$0.64	$64.00
Snacks / Chocolate	100 chocolates per box	4	$12.50	$50.00
				$1,319.00

Exhibits

Exhibit 1: Game Board* (in starting condition)
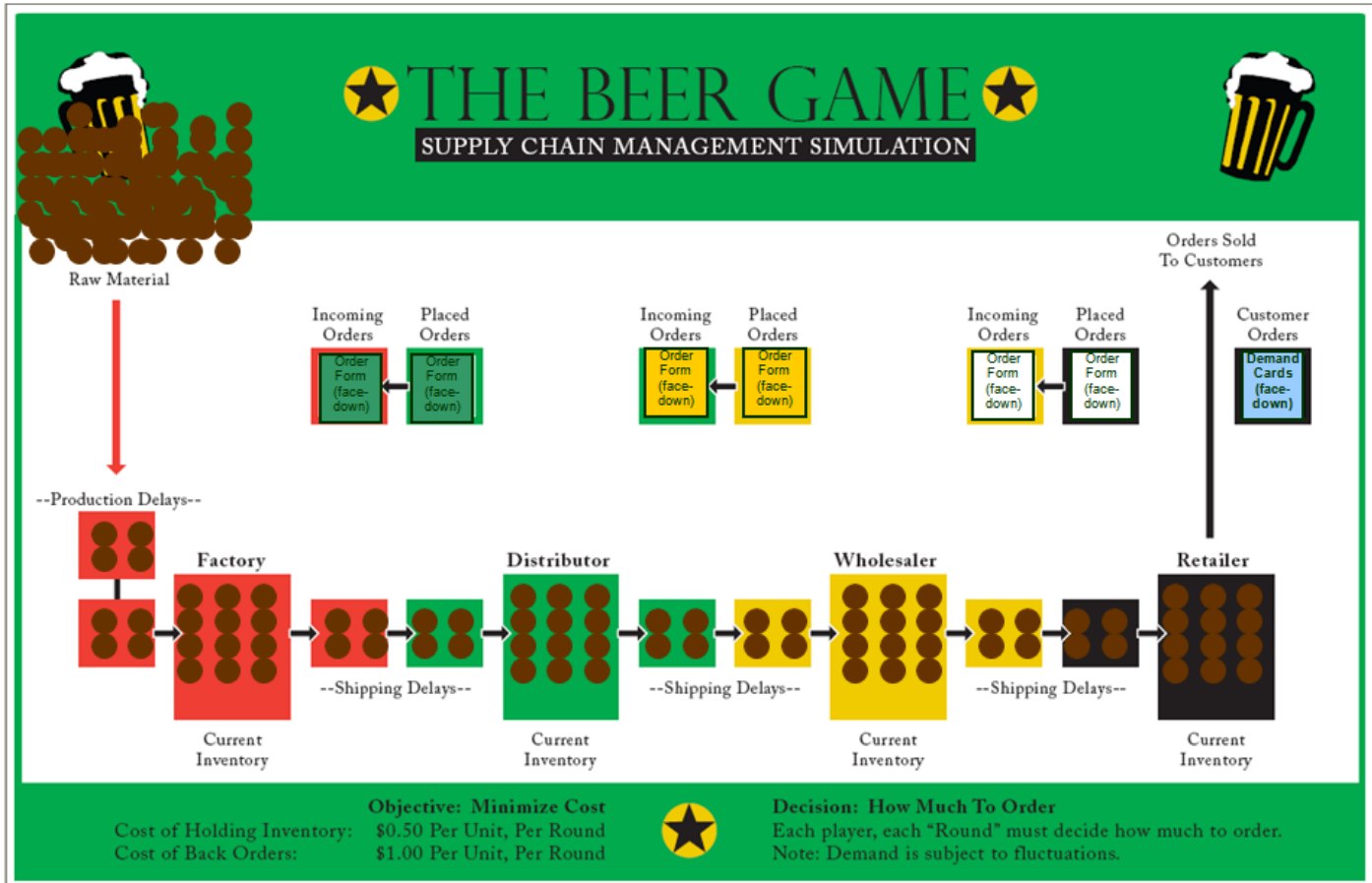
*Board design adapted from Sterman (1989).

Exhibit 2: Board "Kit" of game pieces

Exhibit 3: Backlog Class Example

Unique Product – Backlog is possible

- You have exclusive retail rights to a product
- Record the following transactions to keep track of your inventory / backlog:

Period	(a) Starting Inventory (= previous week's Ending Inventory)	(b) Quantity Received (from supplier)	(c) Incoming Order (from customers)	(d) Ending Current Inventory / Backlog (a) + (b) - (c) =
1	0	8	3	0 +8 -3 = 5
2	5	4	15	5 +4 -15 = -6
3	-6	4	20	-6 +4 -20 = -22
4	-22	50	20	-22+50-20 = 8

- How many are on the shelf if we have a backlog?
  None – we must ship out all inventory to the "waiting" customers

Exhibit 4: Animated PowerPoint Instructions Example

STEP 4: ORDER MORE *(Factory Different)*

★ THE BEER GAME ★
SUPPLY CHAIN MANAGEMENT SIMULATION

Raw Material

Orders Sold To Customers

--Production Delays--

Factory

Incoming Orders | Placed Orders | Order Form (face-down)

Distributor

Incoming Orders | Placed Orders | Order Form (face-down)

Wholesaler

Incoming Orders | Placed Orders | Order Form (face-down)

Retailer

Customer Orders | Demand Cards (face-down)

--Shipping Delays-- | --Shipping Delays-- | --Shipping Delays--

Current Inventory | Current Inventory | Current Inventory | Current Inventory

Objective: Minimize Cost
Cost of Holding Inventory: $0.50 Per Unit, Per Round
Cost of Back Orders: $1.00 Per Unit, Per Round

★

Decision: How Much To Order
Each player, each "Round" must decide how much to order.
Note: Demand is subject to fluctuations.