

**Exploring the Impact of Instructional Sequencing on Learning**  
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**Problems addressed and research questions:**

This experiment explores how the sequence of instruction affects learning, or more specifically how the sequencing of “coaching” as defined by Collins (Collins, Brown & Holum 1991) within his Cognitive Apprenticeship model, affects deeper understanding.

While instructional design theories agree on the need to provide guidance that directs and/or facilitates learning, they differ regarding the optimal sequence for when such practices should be used. Some, like Alan Collin’s Cognitive Apprenticeship model, and, even more drastically, in Eleanor Duckworth’s Critical Explorations technique (Duckworth 2003), consider initial hands-on activities without explicitly prescribing instructions useful to motivate students’ sense of cognitive dissonance, thus encouraging self-discovery. Expert strategies are intentionally withheld, at least to the degree that learners are challenged to learn through inference and rational ingenuity rather than imitation. The content of coaching is related to specific events that arise as students attempt to accomplish the task (Caver, 2006). Other instructional design models, like LEGACY (Schwartz, Lin, Brophy, & Bransford, 1999) precede hands-on activities with discussions, modeling, and expert testimony in order to guide students’ later work. While cognitive dissonance is still promoted through the use of “Challenges,” actual hands-on activities often do not begin until learners have discussed their own ideas in relation to those of experts. And finally, in Objectivist cases, such as historic applications of the Dick and Carey model (Dick, 1996), discussions of users’ opinions are avoided altogether. Here, instruction focuses on promoting students’ adoption of expert strategies provided by the instructor.

While instructional sequence could encompass many different forms, only one, simplified variation was investigated in this experiment. Specifically we compared students’ achievements based on whether or not they were provided with coaching prior to or after a hands-on session experimenting with a business simulation game called Lemonade Stand (<http://www.ae4rv.com/games/lemonade.htm>). The students were assessed on a terminology comprehension test as well as an open-ended essay question designed for deeper understanding (appendix page5, 4).

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### Hypothesis

We hypothesized that pre-exploration coaching (appendix p.3) would help students make more meaningful observations and inferences by focusing their attention on the most salient issues in the game thus maximizing their “on-task” exploration time. This consequently would allow them to gain a deeper understanding of how the simulated business system operates than those students who did not receive coaching until after their exploration time was completed. However, students given the same coaching after first experimenting with the simulation but just before taking post-test assessments would demonstrate higher comprehension scores (having just reviewed the material) but a less sophisticated system’s knowledge.

**Methodology:** (procedures; data collection, analysis, etc)

### Experimental Design - Day one:

Activities	Descriptions	
<b>Pre-Test</b> 5 minutes	Took pretest to establish competency with similar computer simulations and games to lemonade stand and math skills	
<b>Lesson Introduction</b> 10 minutes	Situated students into groups at computers with Lemonade Stand loaded.	
	Explained student’s objective: To experiment with the game to understand how to make the most money running the virtual business.	
	Introduced Lemonade Stand interface, explaining how to use the program. Demonstration included running through one day of Lemonade sales, pointing out how the game provides feedback. No strategies or explanations of cause and effect were given	
	Provided observational journal and instructed how one person in each pair of students will be the treasurer, responsible for recording each day’s transactions and general observations.	
<b>Experimental Lesson Sequence</b> 20 minutes	<b>Group 1:</b> Played game	<b>Group 2:</b> Reviewed expert testimony and terminology definitions
	<b>Group 1:</b> : Reviewed expert testimony and terminology definitions	<b>Group 2:</b> Played game
<b>Assessments Part I</b> 10 minutes	Took Comprehension exam of expert testimony	

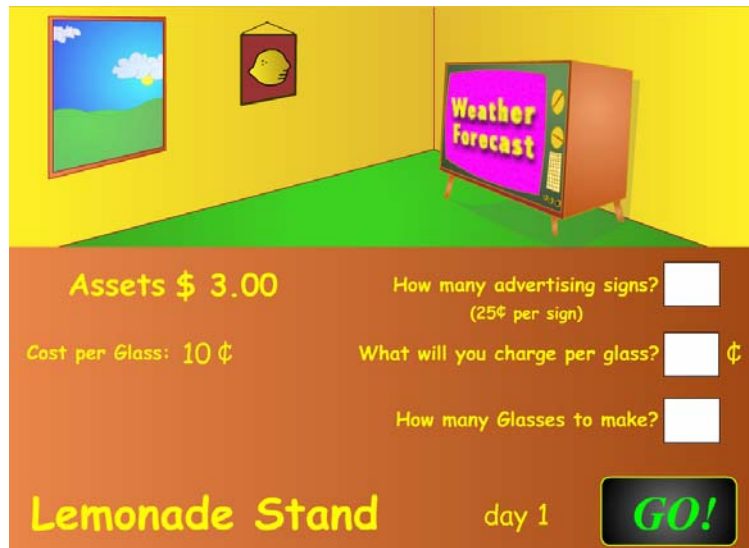
### Experimental Design – Day Two:

Activities	Descriptions
<b>Explanation of Essay</b> 5 minutes	Explained the class that they had to write up a brief essay style question providing a guide for other students to understand the game and maximize their profits. They were requested to write the guide in steps.

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<b>Essay Test</b> 15 minutes	Students answered essay question regarding best strategy for maximizing profit.
<b>Discussion</b> 10 minutes	Led discussion to explain all the rules of the game, the math concepts (Assets, Net Profit, Gross Profit, Expenditures, Advertising Expenditures). Answered any questions students had about math concepts or the game in general.
<b>Competition</b> 20 minutes	Had the students split into groups of two and play the game. They were told to try their best at the game and to use their strategies to maximize profit.

The experiment took place in a public fifth grade math class in the course of two single 45 minute class periods. The 27 students were randomly divided into two experimental groups and each received the same instructions, materials and guidance differing only in instructional sequence. The class initially received and completed a pre-test (appendix p.1) consisting of questions pertaining to their previous experiences regarding video games and selling as well as a section on terminology that would appear in the Lemonade stand game. The pre-test was followed by oral instructions of the day's activities and an overview of the lemonade software that included a handout (appendix p.2).



The class was then randomly divided into two groups with the first group aggregating towards the front of the room to receive “coaching” while the second group formed their partnership and began exploring the game. Following 10 minutes of coaching, the first group paired off and began exploring the software. The group that began using the computers first, completed their 20 minute exploration and then moved to the front of the room to receive their coaching. Thus one group received the coaching before exploring the software and one group received the same coaching afterwards.

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Day	Assets	Cost Per Glass	Weather Forecast	How many advertising signs?	How much charged per glass?	How many glasses made?	You Sold	Gross Profit	Net Profit	Notes & Observations
ex.	\$2.78	\$0.10	Hot/Sunny	2	0.15	15	15	\$2.25	\$0.25	
1	\$3.00									

Throughout the exploration period the students were visibly excited and often asking a neighboring group how much money they were earning. The groups appeared to work harmoniously as one member would keep track of the data on the data collection sheet (shown above) while the other navigated the game. Although roles appeared to develop within each group it generally appeared that both members were actively involved in the decision making process. From the very beginning, misconceptions were being made by the students. Some were purely focused on selling the highest number of glasses of lemonade, not realizing that their business was actually losing money, while others misinterpreted the weather forecast as the actual weather conditions. Most of the students seemed eager to speak about their entrepreneurial experiences and the teacher informed us that the students were talking about the game and strategies long after we left the classroom.

We began the second day by administering a post test that consisted of two essay questions assessing their understanding of the economic model embedded in the game (appendix p.4). The students were instructed to write a step by step guide of how to play the game in a manner that would maximize their profits. The instructions also asked for tips and strategies that the student found most useful. The students were orally informed that we were hoping to share their best strategies with other 5<sup>th</sup> graders and to provide the most detail that they possibly could.

Upon completion of the essays, we a led a whole-class discussion about strategies that were used by the students and further explored the definitions of the terminology present in the game. The conversation was lively as the students were eager to share their ideas. Although full class discussion does not give a voice to all students, those who participated (more than half) appeared to have had a conceptual grasp on the terminology and insight into the economics of sales as demonstrated here:

**Question:** What are advertising expenses?

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**Answer by student:** Money you pay for getting advertising signs.

**Question:** What is gross profit?

**Answer by student:** A profit you gave to make lemonade.

**Answer by student:** How much money you made.

**Answer by another student:** Profit you make before you subtract your advertising expenses.

**Question:** What strategies did you find useful in playing the game?

**Answer student:** Never make more than 15 glasses, as the weather forecast is not always correct.

**Answer by another student:** I disagree. I made 60 glasses and sold them all

**Answer by another student:** Always charge more than your cost per glass

**Answer by another student:** Never charge more than 50 cents a cup, people would never buy it.

**Response by another student:** I disagree, I sold mine for 70 cents and sold them all

Following this discussion we informed the students that they would now have the opportunity to demonstrate their strategies and experiment with their uncertainties in a 20 minute competition. The students were extremely excited and had a hard time waiting for all of the teams to be ready before they began. There was a sense of urgency in the room as the students compared their scores to that of other groups. Following the 20 minutes of play, we announced the top 5 earners in the class. The team that came first landed up making over \$130 in profits. The next few teams scored between \$40 and \$70. The winning team was asked to explain their strategies to the class. Their paraphrased responses were as follows: On rainy days we did not make or sell anything, as rarely anyone would buy lemonade. When the forecast was hot and sunny we made a lot of lemonade, like 50 glasses and made the price high. We usually sold all of it.

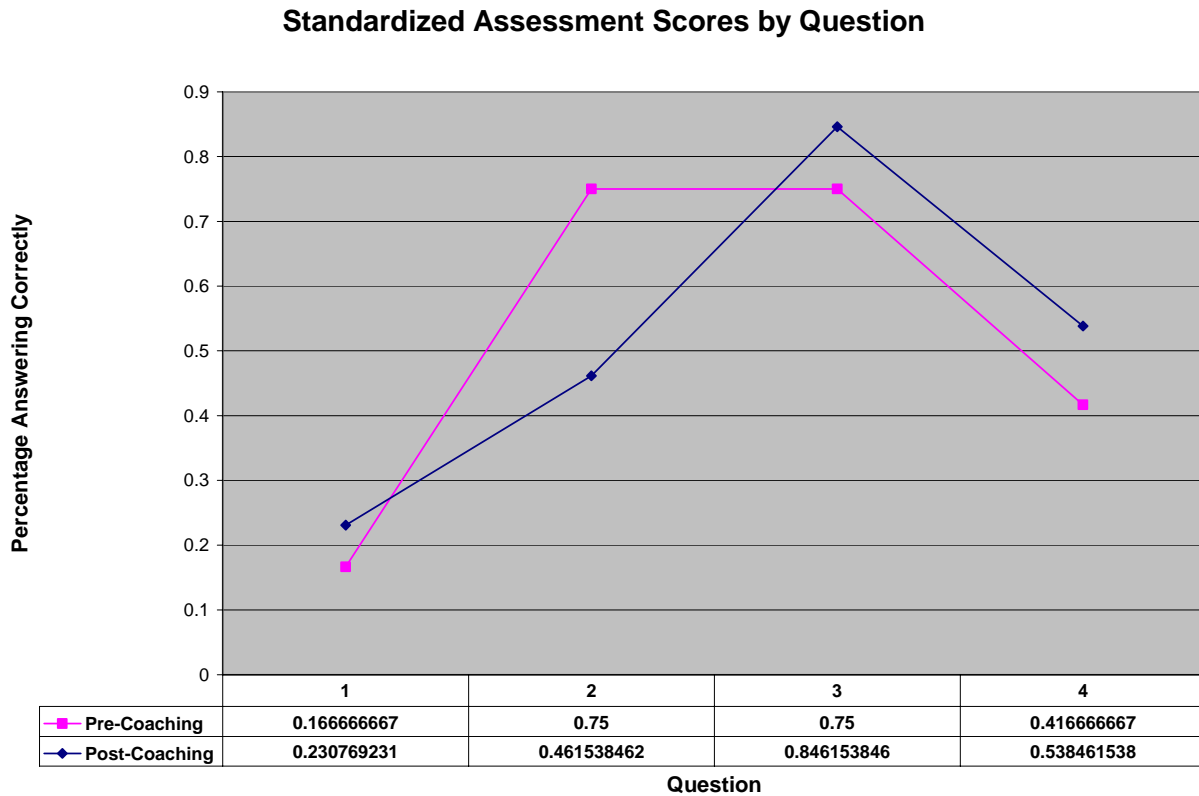
### **Results:**

Initial considerations of the results demonstrate little difference between the two groups. Both groups demonstrate non-significant differences in prior experience with similar computer games and real-world sales experiences. The pre-coached group demonstrated more familiarity with the business terminology used, but not significantly so. Likewise, the two post-assessments overall scores showed no significant differences. Both groups seemed to be equally competent in terminology and their understanding of how the Lemonade Stand's economic system model operates. Yet deeper analysis of the data revealed some surprising and significant differences.

The comprehension post-test (appendix p.5) was comprised of three multiple choice and one fill-in-the-blank questions. It required students to correctly define business terminology that were used throughout the game and explicitly explored during the expert coaching sessions. A paired-

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differences test of each groups' average likelihood of getting individual questions correct, showed a significant difference at the .05 significance level; showing that each group actually did answer particular questions differently, even though their overall scores were nearly identical.



Above, it can be seen, as predicted, that students in the post-coaching group who had discussed the terminology just prior to the assessment tended to correctly define the terminology more often than those in the pre-coaching group. If the slightly higher familiarity demonstrated by the pre-coach group in the pretest was adjusted for, these differences would increase slightly, however this analysis was not performed. The exception to this general trend is question number two.

Question two asked students to define net profit, a term considered by the teacher and ourselves to be the most conceptually complex in that it is defined as a relationship between other abstract concepts (such as gross profit and total costs) rather than as a directly observable measure. While both groups received the definition for net profit during their coaching session, the pre-coached students actually asked about net-profit prior to its explanation, and continued to ask relevant questions about terminology and game play. In contrast, the post-coached students demonstrated an eagerness to share their observations and accomplishments in the game and seemed to ask fewer questions about terminology. In both cases any questions regarding information found on

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the expert testimony hand-outs were answered. Without a video taped account of these two sessions it is difficult to conclude whether or not the coverage of net profit was equivalent between the two groups.

Nonetheless there seemed to be differences in the nature of students' questions and comments in the two coaching sessions that were at least in part related to the sequencing used. Before playing the game students (in the pre-coached group) asked mostly about terminology and how the game itself was going to work. In the post-coached group, having just finished playing, while students did express interest in hearing about what the terminology meant, they were noticeably more eager to talk about their own experiences.

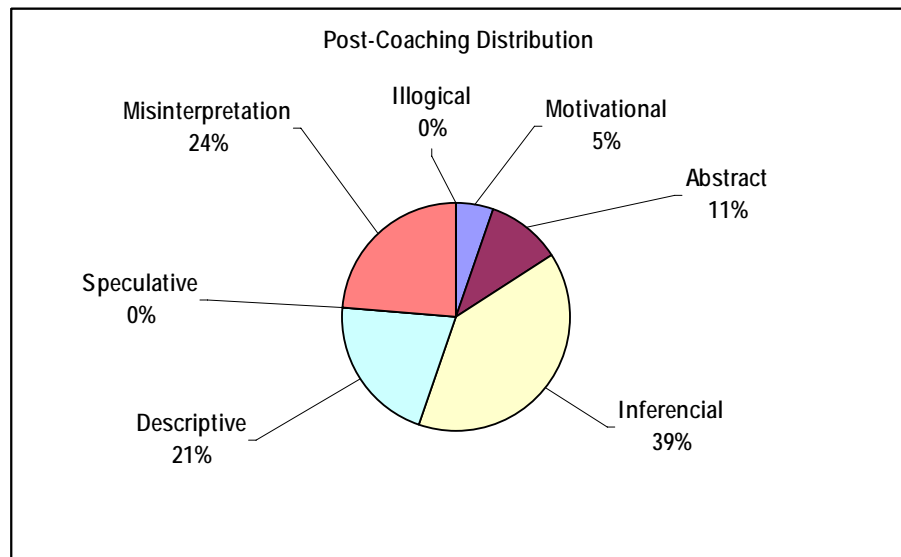
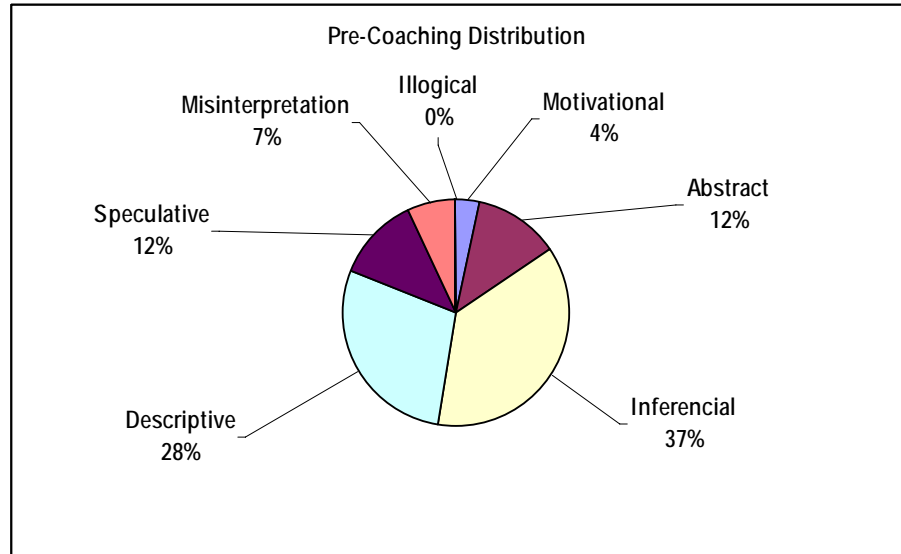
Findings from the systems knowledge post-test, which asked students to give step by step advice regarding how to make the most profit in the lemonade stand game, seemed to suggest that there were in fact differences in communications styles correlated to sequencing. Scores were qualitatively rated using two methods. We itemized each statement made by a student, determining which of the following categories it belonged to:

Category	Description
• Motivational	• Usually perspectives or motivational or simply rationalizing statements – occasionally providing value of activity – Used to analyze statements
• Complex reasoning relating abstract concepts	• Inference based on abstractions of observations. Connections with relationally complex reasoning. – Used in analysis to see the connections and transitions between statements
• Simple inference of rules and simple abstract relationships	• Based on experience or Basic Inference (1 off inferences based on simple observable facts in the game) – Immature Complex Abstract Reasoning
• Descriptive without making suggestions	• Descriptive/Observational without suggestion - Used to analyze statements
• Speculations or unfounded concrete suggestions	• Pertaining to game not based on experience or observation or concrete/arbitrary unfounded suggestions
• Slight misinterpretations, but conceptually on the right track	• Pertaining to game not based on experience or observation or concrete/arbitrary unfounded suggestions – usually on the right track – Used to analyze statements
• Illogical or blatantly erroneous reasoning	• On the wrong track – Used to analyze statements

The second rating system simply gave students an overall competence score ranging from 0 to 5. A score of 0 indicated no understanding of the terminology or strategies and 5 was a comprehensive understanding of the economics model presented in the game.

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To insure consistent scoring three researchers collectively established a list of types of statements and reasoning that qualified for each of the ratings described above, then independently rated each students essays, and ultimately discussed their opinions until coming to a consensus on final scoring. While the overall competence ratings showed no significant differences, the categorical distribution of statements were significantly different based on a Chi Squared test at the .05



significance level. The actual categorical distributions for both groups, as distribution percentage averages of each respective group, are shown here.

On average students in the pre-coached group included more statements in their essays and fewer misinterpretations along with more speculations. It is important to note that *speculations* entailed all statements (correct in their assertions) that would have otherwise been categorized as *inferential* except that they failed to be supported by experiential or logical explanations.

### Conclusion:

The results of this study may or may not support the original hypothesis that coaching prior to hands-on learning activities will prime students' meta-cognitive strategies and result in a deeper

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systems understanding that may not be captured in standardized testing that favors recall of memorized information. Measures of overall competence, both quantitative and qualitative did not observe significant overall differences of the kind predicted. Yet non-significant differences did demonstrate tendencies in-line with predictions, and there were significant differences in the types of reasoning students used in explaining their understanding of how the game's economic model operated. Specifically, categorical distinctions of their statements indicated that the pre-coaching group had fewer misconceptions; furthermore, if unfounded but correct assertions were indicative of inferential reasoning, the pre-coaching group also demonstrated significantly more complex reasoning than the post-coaching group. However our predicted hypothesis that the systems knowledge essays with higher percentages of statements based on inferential reasoning and abstractly connecting concepts would also correlate to higher overall competency ratings, was not found to have significant correlations.

Learning is complex. While this study did find that the sequence of coaching can cause qualitative differences in the nature of students reasoning about complex economic systems, the impact that these differences have is unclear. In part this is due to limitations inherent to running this study in a 45 minute class periods within a single classroom involving a small sample size and with assessments brief and likely insensitive to subtle differences in knowledge acquisition, understanding, retention, and transfer.

### **Surprising observations**

Some of our surprising observations included:

- The inter-group differences for the definition of net profit as well as the distinct qualitative differences in their systems knowledge answers.
- The range of personal perspectives on what qualifies as “success” in business e.g. offering fair prices versus maximizing profit versus offering lower prices to communities in need of assistance.
- The lack of a direct correlation between test results and actual game performance. We did though, notice highly aggressive business tactics were useful to quickly gauge customer predispositions.

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- The lack of a recency effect on the post-coaching group with their vocabulary knowledge. They seemed to be focused on sharing their personal experiences as opposed to asking questions.

### **Reflection and Limitations**

Although we were quite pleased with the overall research, we would have liked to perform the study with more participants in hopes of finding further significant differences. Issues that may have affected our results include:

- A misconception by students concerning the forecast versus the actual weather conditions and how these were recorded on the data sheets.
- We attempted to manage two separate instructional sequences within a single classroom. This proved to be a bit hectic and may have influenced our results.
- We did not capture the game data on the second day – observing the differences in their strategies and performance on the second day might have provided some additional information on their understanding
- Some of students might not have possibly been able to articulate their understanding in writing. One-on-one interviews might have provided a better understanding of their knowledge and misconceptions.
- Another exercise that may have proved useful would have been to ask the students to explain their strategies to another student in the classroom. This would have helped them understand their misconceptions and validate their findings and abstract connections. A video taped version of this could have been used in place of the final essay question.
- If we were able to manipulate the game to begin with a similar set of conditions for all students and see how they performed – this could possibly have varied the outcome, as certain students might have got confident initially once they saw repetitions in their outcome and been able to manipulate the data effectively
- The assessments may not be sensitive enough to capture different types of learning with such a short intervention.

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Name \_\_\_\_\_

Group# \_\_\_\_\_

**Before Playing: Please circle your choice and fill in the blanks**

1. Have you ever played a game where you are running a business buying and selling products? (If you answer yes, please write down the name of the game or games)
  - Yes, I have played \_\_\_\_\_
  - No
  
2. Have you ever played a game about selling *Lemonade* before?
  - Yes
  - No
  
3. Have you ever actually set up a public stand and sold lemonade, baked desserts, or other goods before? (If you answer yes, please write down what you sold and where)
  - Yes ....I sold \_\_\_\_\_ at \_\_\_\_\_
  - No
  
4. Please write down what you know about the following vocab words. If you don't know what something means, you can leave it blank.
  - Asset  
\_\_\_\_\_
  - Cost  
\_\_\_\_\_
  - Profit  
\_\_\_\_\_
  - Gross profit  
\_\_\_\_\_
  - Net Profit  
\_\_\_\_\_
  - Advertising Expenses  
\_\_\_\_\_
  
5. Do you think that you would be good at running a business like a lemonade stand? Why or why not?  
  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

## Lemonade Stand Lesson Plan

In this game you run a lemonade stand business. Each day you will be told how much it costs to make each glass of lemonade, and the television will shows you the weather forecast. You begin with \$3.00 that you can use to make lemonade and advertisements.

### Objective:

We are using this game to learn about different ways that math is used in running a business. You can restart the game as much as you like.

### Instructions:

Play the game as demonstrated and try to figure out **HOW** to make as much money as possible. Write down each day's business transactions in the *Business Journal* hand-outs given to you. Next to the data you collect there is room for you to write down ideas you have about how the game works, or how you are experimenting to figure it out.

You will hand these in at the end of class and will use them later for other activities.

### Terminology:

**Assets:**  
An asset is anything a business owns that has value. This includes a business's goods, equipment, property, and money. In this game Assets refers **ONLY** to how much money you currently have.

The screenshot shows a newspaper clipping from the 'Lemonville Telegraph' with a headline 'Beautiful Day in Lemonville' and a weather forecast of 'Sunny and Pleasant!'. Below the clipping is a business journal page for 'day 1' with the following data:

<b>Assets</b>	\$ 2.92	<b>Gross profit:</b>	\$ 1.08
Cost per glass	11 ¢	<b>Advertising expenses:</b>	\$ 0.50
You charged	18 ¢ per glass.	<b>Product expenses:</b>	\$ 0.66
You made	6 glasses.	<b>Total expenses:</b>	\$ 1.16
You sold	6 glasses.	<b>Net profit:</b>	\$ -0.08

At the bottom of the journal page, it says 'Lemonade Stand day 1' and a 'GO!' button.

**Gross Profit:**  
Total money made in sales  
= Number of glasses sold X price per glass

**Advertising Expenses:**  
Total money spent in advertising  
= Number of Ads X price per Ad

**Product Expenses:**  
Total spent making lemonade  
= Number of glasses made X price per glass

**Total Expenses:**  
Total money spent doing business  
= Produce Expenses + Advertising Expenses

**Net Profit:**  
Total amount of money you made after you subtract what you spent  
= Gross Profit - Total Expenses

## Secrets to Running a Successful Business – What experts say:

Anyone can take a chance and get lucky, but only those who are smart about running a business succeed time and again. Here is what experts say:

### 1) Ask yourself questions

- **How much will customers be willing to spend per glass? ...is it affected by weather? ...by advertising?**

Answer these questions by experimenting to find out the highest price someone will pay for a glass of lemonade on:

- on a Sunny and Hot day with no advertisements
- on a Sunny and Pleasant day with no advertisements
- on a Cloudy day with no advertisements
- on a Rainy day on a Hot day with no advertisements
- on a Sunny and Hot day with 1 advertisement?

- **How many glasses will customers buy? ...is it affected by weather? ...by advertising? ...by how much you charge per glass?**

Answer this by running different experiments, can you figure out how?

- **If price effects how many glasses are sold, is it more profitable to sell fewer glasses at higher prices or to sell more glasses at a lower price? What calculations can you use to figure this out?**

### 2) Use your Business Logs

Your datasheets record how successful your business is each day given the different decisions you make. One day you may have made the following 3 decisions:

- to charge 20 cents per glass
- to make 10 glasses
- to buy 1 advertisement.

**But how does any particular decision influence the total number of glasses sold?**

**In order to know for sure, you need to do a comparison between days that are the same in every way, except the one you are trying to figure out.** For example to really know if advertising made a difference you might always charge 20 cents per glass, always make 10 glasses and then try buying different numbers of ads. Since you can't control the weather you may have to do this over and over again until you can compare results for days that had the same type of weather.

### 3) Experiment

Remember when you play the game you can start over whenever you like. So start by trying to figure out HOW to make as much money as possible, restart as often as you need in order to test your theories, and then when you feel ready - start a game where you put your ideas in action!



Name \_\_\_\_\_

Group# \_\_\_\_\_

**After Playing (part 2): Please answer the following questions**

1. What are your product expenses?
  - a. The total cost of glasses of lemonade sold
  - b. The cost per glass of lemonade
  - c. The total cost of all glasses of lemonade made
  - d. The total cost of all glasses of lemonade and advertisements made
  
2. What is Net Profit?
  - a. The Total Expenses minus the Gross Profit
  - b. The total money made in sales minus the Total Expenses
  - c. The total money made in sales
  - d. The total money made per glass of lemonade
  
3. What is an Asset?
  - a. A sale of a glass of lemonade
  - b. An advertisement that you have paid for
  - c. The cost of making a glass of lemonade
  - d. The money or a valuable item owned by your company

How do you calculate your total advertising expenses?

Advertising Expenses = \_\_\_\_\_