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## Facilitator Information

### Learning Objectives (for content & process)

After completing this activity, learners should be able to:

- Explain what a **Work Breakdown Structure (WBS)** is and how it is used;  
create and interpret a WBS using paper or software tools.
- Explain what a **Gantt Chart** is and how it is used;  
create and interpret a Gantt Chart using paper or software tools.
- Explain **Critical Path Analysis (CPA)** is and how it is used;  
(aka Program Evaluation and Review Technique)  
perform and interpret a CPA using paper or software tools.

This activity should help learners develop teamwork and management skills.

### Prerequisites (for content & process)

Before starting this activity, learners should have:

- Basic familiarity with baking (e.g. middle school home economics).  
(This activity could be “translated” into other contexts without much difficulty.)
- Previous experience with POGIL (useful but not strictly necessary).

## Preparation

1. Print the Activity (2/team), Cookie Recipe (2/team), Step Cards (1 set/team), Scheduling Worksheet (2-4/team, 11x17 if possible, double-sided OK).
2. Cut the Step Cards into pieces (or have teams do this).
3. optional: provide 1 computer / team for take notes, creating WBS, creating Gantt Chart
4. optional: provide 1 batch of cookies for inspiration

## Activity Notes

- If time is limited, skip:
  - (05 min) I. Time Estimates: all
  - (08 min) II. Steps: 2,4
  - (10 min) III. Time Estimates for Steps: 4
  - (12 min) IV. Dependencies: 3,4
  - V. Resources: any or all
  - VI. Critical Path Method: all
- The facilitator should spend a minute or two introducing the activity.
- While student teams work, the facilitator should circulate among the teams to monitor progress and help with problems, although the facilitator should avoid providing or confirming answers to any of the key questions.
- I.4. Report out or write on board: 2 team estimates.
- II.2. Remember: blend oatmeal, grate milk chocolate, chop nuts, & preheat oven.
- II.4. Report out may not be needed here.
- III.2 or 4. Report out or write on board: total prep time, insights.
- IV.4. Report out: insights.

## Things to Do

- Estimate story points (1/2/4/8) not minutes, to simplify estimation & charting.
- Reduce total time required, especially for earlier sections.
- Add more reporting out to activity or activity notes.
- ? Use larger schedule and place tasks & bars graphically
- ? Add other (non-cookie) contexts – suggestions are welcome.
- ? Add critical chain.

## Activity History

2010-06 drafted by Clif Kussmaul [clif@kussmaul.org](mailto:clif@kussmaul.org)  
2010-06 tested by Salter family, reviewed informally at mid-Atlantic POGIL meeting, revised  
2010-09 tested in CS210, revised  
2011-07 added photos, revised  
2011-11 tested in FYS117 and CSI210, revised

## Introduction

start time:
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This activity will help you learn about project scheduling, including challenges & useful techniques. To do this, you will explore ways to estimate how long it will take to make a batch of 40-50 cookies.

Before you start, complete the form below to assign a role to each member. If you have 4 people, combine Speaker & Reflector. If you have 3, combine Speaker & Technician, and Recorder & Reflector.



Team	Date
Team Roles	Team Member
<b>Recorder:</b> records all answers & questions, and provides copies to team & facilitator.	
<b>Speaker:</b> talks to facilitator and other teams.	
<b>Technician:</b> handles cards, worksheets, & computer software.	
<b>Manager:</b> keeps track of time and makes sure everyone contributes appropriately.	
<b>Reflector:</b> considers how the team could work and learn more effectively.	

*Reminders:*

1. *Recorder: Note the time whenever your team starts a new section or question.*
2. *Write legibly & neatly so that everyone can read & understand your responses.*

start time:
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***(05 min) I. Time Estimates for Recipe***

1. (1 min) For this question, **do not over-think or discuss** your answers.

Write down your estimates individually, and then give to the recorder to enter in the table below.

Estimate the time needed to make a batch of 40-50 cookies for:

- a. 1 cook alone                      b. 5 cooks together

<b>Team Member:</b>	<b>#1</b>	<b>#2</b>	<b>#3</b>	<b>#4</b>	<b>#5</b>	
<b>a. 1 cook working alone</b>						
<b>b. 5 cooks working together</b>						

2. (2 min) Estimate **as a team** how long it would take for (a) **1 cook** (b) **5 cooks** to make a batch of 40-50 cookies. Write your team estimates in the last column in the table above.

3. (2 min) Summarize any insights or concerns raised in the discussion. Review progress with the facilitator before continuing.

## *(08 min) II. Steps in Recipe*

start time:
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1. (1 min) Sort the **16 step cards** into **5 groups**: Dry, Flavor, Wet, Bake, Cleanup
2. (3 min) Read through the recipe. Note which steps are **explicitly** listed in the recipe and which are **hidden**. List 3-5 other steps that are in the recipe but not on cards. Note any insights or problems you encounter, if any.

Hidden Steps:

Insights or problems:

3. (2 min) In the “Group / Step” column of **Scheduling Worksheet 1**, write an outline with all groups & steps. Put each group label in its own lettered row, and put each step in a group into a numbered row below the group row. Do not worry about putting the groups or steps in any particular order – alphabetical order is fine.  
Option: If you have a computer, you could create this outline in the first column of a spreadsheet, and use formatting to visually distinguish groups from steps.

This outline is called a **Work Breakdown Structure (WBS)**.

A WBS can be useful to organize a project and identify missing steps, particularly if you have templates with common headings or WBS examples from similar projects. For complex projects, the WBS may have 3 or more levels and require multiple pages.

4. (2 min) If there is time, consider other grouping for the steps, and list their pros & cons. Review progress with the facilitator before continuing.

start time:
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## *(10 min) III. Time Estimates for Steps*

1. (3 min) Divide the cards among team members.

**Individually** estimate the time to complete each step and write the estimated time on each card.

Option: You could also add the times to the “time” column in the worksheet or spreadsheet.

**Don't over-think.**

2. (2 min) Add all of the step times: \_\_\_\_\_

Is this how long the recipe would take for **1 cook**? \_\_\_\_\_

Describe circumstances under which this **would** and **would not** be true.

3. (2 min) Divide the sum of step times by 5: \_\_\_\_\_

Is this how long the recipe would take for **5 cooks**? \_\_\_\_\_

Describe circumstances under which this **would** and **would not** be true.

4. (3 min) Which steps are most difficult to estimate? Why? How could these estimates be improved?

Summarize the discussion. Review progress with the facilitator before continuing.

start time:
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## ***(12 min) IV. Dependencies between Steps***

1. (4 min) Assume there is just 1 cook, and organize the steps by placing the cards in order from left to right (or top to bottom). Try to minimize the total time the recipe will take. Review progress with the facilitator before continuing.
2. (3 min) Copy the schedule onto **Scheduling Worksheet 1**, with a bar showing the start & stop time for each step. Hint: Check the total time and adjust the horizontal axis or get more sheets if necessary.
3. (2 min) When there are many steps, it can be useful to look at groups. What is a logical start and stop time for a **group of steps**? Add these to the worksheet as bars. This is a **Gantt chart**; it was developed in the early 1900s by Henry Gantt.
4. (3 min) How could each step's **status** (e.g. not started, in progress, finished) be shown on the chart? How useful would this be to review the status of the entire project? What other info would be useful? Review progress with the facilitator before continuing.

**(12 min) V. Resources**

start time:
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Assume that **2 or more cooks** are working together to make the recipe.

Each cook can do just one step at a time, but different cooks can do different steps at the same time.

1. (3 min) On each card, note the steps that must be completed immediately before that step can be started.
2. (3 min) Organize the steps by placing the cards in order from left to right (or top to bottom), with a row (or column) for each cook. Try to minimize the total time the recipe will take, without violating any of the dependencies you identified above.  
Review progress with the facilitator before continuing.
3. (2 min) Copy the new schedule onto **Scheduling Worksheet 2** (or a spreadsheet), with a bar for each step and group. This is a **resource Gantt chart**.
4. (2 min) In the columns labeled “cook1”, “cook2”, etc, indicate the cook responsible for each step. A table like this, showing who is responsible for which steps, is a **Linear Responsibility Chart**. If there are different roles (e.g. review, test, approve), they would be indicated in each cell.
5. (2 min) Assume that one food processor is required to blend oatmeal, grate chocolate, & chop nuts. How could you include this in the schedule and Gantt chart?



start time:
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## ***(10 min) VI. Critical Path Method***

1. (3 min) Which steps **cannot be shifted** (earlier or later) without changing the total time for the recipe? On the schedule worksheet, outline or highlight these **critical** steps.

2. (3 min) Which steps **can be shifted** (earlier or later) without changing the total time for the recipe? For each of these **floating** steps, use the schedule worksheet or card to indicate the earliest and latest start time that would not change the total time.

The critical sequence of steps constitutes the **critical path**. The process of identifying the critical path is the **Critical Path Method** (a.k.a. Project Evaluation & Review Technique (PERT)); it was developed in the 1950s by DuPont and by Booz Allen Hamilton and the US Navy.

3. (3 min) When could a floating step become part of the critical path?  
When could a critical step stop being part of the critical path? What are the implications of this?  
Review progress with the facilitator before continuing.

## Review Questions

1. What does the acronym WBS stand for?
2. Why does adding more people not always shorten the time for a project?
3. Describe a Gantt chart.
4. What chart would you use to keep track of who is doing what?
5. What is the name for the set of steps that should not be delayed?

## Applications

1. Team Meeting Minutes (TMM) – see common description (separate doc) and rubric (below).
2. Personal Reflection Memo (PRM) – see common description (separate doc).
3. Create a WBS and Gantt chart for academic requirements, including general education and major(s) and/or minor(s).
4. In a complex project with multiple people and other resources, and with many steps & dependencies between steps, creating an efficient schedule may be difficult. Fortunately, there are tools (such as *Open Workbench* and *Microsoft Project*) that can create a schedule automatically from a set of tasks & dependencies. Use such a tool to create a schedule (e.g. for the cookie recipe, or for a set of academic requirements).

## Resources

Brooks FP. 1995. *The Mythical Man-Month: Essays on Software Engineering, Anniversary Edition*. 2nd ed. Addison-Wesley Professional.

*Classic collection of essays on software engineering and project management in general.*

Brown A. Chips for Sister Marsha. Episode EA1C05 of *Good Eats* (TV show). Food Network.  
<http://www.foodnetwork.com/good-eats/three-chips-for-sister-marsha/index.html>

*Several good chocolate chip cookie recipes & relevant background information.*

Frame JD. 2003. Tools and techniques for keeping the project on course. Ch 6 in *Managing Projects in Organizations: How to Make the Best Use of Time, Techniques, and People*. 3<sup>rd</sup> ed. Jossey-Bass.

*Classic book on project management.*

Goldratt EM, Fox J. 2004. *The Goal: A Process of Ongoing Improvement*. North River Press.  
*Business novel on economic theory, process improvement, & critical chain method.*

Newbold RC. 1998. *Project Management in the Fast Lane: Applying the Theory of Constraints*. CRC Press.

*Good book on applying Goldratt's critical chain approach.*

**Team Meeting Minutes (TMM): Rubric**

<b>SPECIFIC CRITERIA</b>	<b>RATING</b>	<b>COMMENTS</b>
I: Comprehensively synthesizes Work Breakdown Structure.	/ 3	
II: Comprehensively synthesizes Gantt Chart.	/ 4	
III: Comprehensively synthesizes Resource Gantt Chart.	/ 3	
IV: Comprehensively synthesizes Critical Path Analysis.	/ 4	
<b>COMMON CRITERIA</b>	<b>RATING</b>	<b>COMMENTS</b>
Begins with a summary of the activity; ends with a summary of questions, and a list of action items, if needed.	/ 3	
Mechanics & format: Work is neat, well organized, & clearly provides all required information, including team member roles & timing data.	/ 3	
<b>TOTAL</b>	/ 20	

## Cookie Recipe

Assume that all needed equipment & ingredients are available.  
Variations of this recipe have circulated online for over 20 years.

Cream the "wet" ingredients  
(in a electric mixer, if possible):  
2 cups (1 lb) butter or margarine  
2 cups white sugar  
2 cups brown sugar  
2 tsp. vanilla

Mix in one by one:

4 eggs

In a bowl, mix the "dry" ingredients:

4 cups flour 2 tsp. baking soda  
1 tsp. salt 2 tsp. baking powder

Add the "dry" to the "wet".

Mix in:

5 cups "blended oatmeal"  
(Take 5 cups of rolled oats (regular or instant),  
put them in a blender or food processor,  
and process them into gritty flour.)

Add:

2 12-oz. bags semi-sweet chocolate chips  
(different sizes are good)  
8-12 oz. of milk chocolate, grated  
3-4 cups chopped pecans or walnuts,  
12 oz. coconut (optional)

Chill the cookie dough for 15 minutes.

Roll into golf-ball-sized balls (or bigger),  
bake for 9-11 minutes at 375.

(Remember to preheat the oven.)

The cookies will be browned but soft inside.



## Facilitator – Answer Key

### (05 min) I. Time Estimates for Recipe

1. There may be wide variation, depending on the learners and their baking experience. This is fine.
2. Teams usually have more confidence in group estimates than individual estimates.
3. Possible insights:
  - More people may reduce time, but with limits. (9 women can't make a baby in 1 month).

### (08 min) II. Steps in Recipe

1. This makes the teams look at the individual steps. Skipping this step does not save any time.
- 2.a. Some hidden steps: preheat oven; crack eggs; blend oatmeal; grate chocolate; chop nuts.  
It is not critical that teams identify particular steps, just that hidden steps exist.
- 2.b. Missing tiny steps (e.g. preheating) can cause big delays.  
It isn't always obvious how much detail is necessary, and what is understood.
3. See Facilitator – Worksheet

### (10 min) III. Time Estimates for Steps

1. The estimates don't have to be good – no need to take time for careful estimates.
2.  $\text{sum of steps} <> \text{total time for 1 cook}$ , since many steps overlap
3.  $\text{sum} / N <> \text{total time for } N \text{ cooks}$ , since they can't all be busy the entire time
4. Estimates can be improved by: research (talking to experts), data collection (from similar projects).

### (12 min) IV. Dependencies between Steps

1. Multiple orderings are possible, as long as they seem reasonable.
2. See Scheduling Worksheet 1 – Facilitator Answer Key
3. For a group, use the earliest start time and the latest stop time
4. Status could be shown by filling in each bar from left to right, or by color-coding (e.g. not started, in progress, behind schedule, completed)

### (12 min) V. Resources

1. Some teams may not need to write out dependencies, which is fine.
2. Multiple orderings are possible, as long as they seem reasonable.
- 3,4. See Scheduling Worksheet 2 – Facilitator Answer Key
5. Food processor (or other resource) can be scheduled like another person.

### (10 min) VI. Critical Path Method

- 1-2. Which steps are critical or floating depends somewhat on the team's earlier choices, but there should be a connected sequence of critical steps from the start to the end.
3. If a floating step is delayed or is longer than expected, it can become critical.  
If a critical step is started early or is shorter than expected, it can become floating.  
Thus, the critical path can change during the life of a project (especially for large, complex projects).



# Scheduling Worksheet 1 (use pencil if possible)

Team:

#	Group / Step	time	00	05	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
A																							
1																							
2																							
3																							
4																							
B																							
1																							
2																							
3																							
4																							
C																							
1																							
2																							
3																							
4																							
D																							
1																							
2																							
3																							
4																							
E																							
1																							
2																							
3																							
4																							

# Scheduling Worksheet 2 (use pencil if possible)

Team:

#	Group / Step	time	cook 1	cook 2	cook 3	cook 4	00	05	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	
A																								
1																								
2																								
3																								
4																								
B																								
1																								
2																								
3																								
4																								
C																								
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D																								
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2																								
3																								
4																								
E																								
1																								
2																								
3																								
4																								



## Scheduling Worksheet 1 - Facilitator Answer Key

#	Group / Step	time	00	05	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	
A	BAKE											XX	XX	XX	XX	XX	XX	XX						
1	bake 9-11 min	10														XX	XX							
2	let cool	5																XX						
3	preheat oven	15										XX	XX	XX										
4	roll into balls	5													XX									
B	CLEANUP																		XX	XX	XX	XX		
1	eat cookies	5																				XX		
2	wash dishes	15																	XX	XX	XX			
3																								
4																								
C	DRY				XX	XX	XX	XX																
1	blend in oatmeal	5						XX																
2	blend oatmeal	5					XX																	
3	mix dry ingred	5			XX																			
4																								
D	FLAVOR								XX	XX	XX													
1	add choc, nuts, etc	5									XX													
2	chop nuts	5							XX															
3	grate chocolate	5									XX													
4																								
E	WET		XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX										
1	add dry to wet	5				XX																		
2	chill dough	15										XX	XX	XX										
3	cream wet	5	XX																					
4	mix in eggs	5		XX																				

## Scheduling Worksheet 2 - Facilitator Answer Key

#	Group / Step	time	cook 1	cook 2	cook 3	cook 4	00	05	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
A	BAKE		XX									XX	XX	XX	XX	XX	XX	XX					
1	bake 9-11 min	10	XX													<u>XX</u>	<u>XX</u>						
2	let cool	5	XX															XX					
3	preheat oven	15	XX									<u>XX</u>	<u>XX</u>	<u>XX</u>									
4	roll into balls	5	XX												<u>XX</u>								
B	CLEANUP																		XX	XX	XX	XX	
1	eat cookies	5	XX	XX	XX																	<u>XX</u>	
2	wash dishes	15	XX	XX	XX														<u>XX</u>	<u>XX</u>	<u>XX</u>		
3																							
4																							
C	DRY		XX				XX	XX	XX	XX													
1	blend in oatmeal	5	XX							<u>XX</u>													
2	blend oatmeal	5	XX					XX															
3	mix dry ingred	5	XX				XX																
4																							
D	FLAVOR			XX					XX	XX	XX												
1	add choc, nuts, etc	5		XX							<u>XX</u>												
2	chop nuts	5		XX					XX														
3	grate chocolate	5		XX						XX													
4																							
E	WET			XX			XX	XX	XX	XX	XX	XX	XX	XX									
1	add dry to wet	5		XX					<u>XX</u>														
2	chill dough	15		XX							<u>XX</u>	<u>XX</u>	<u>XX</u>										
3	cream wet	5		XX			<u>XX</u>																
4	mix in eggs	5		XX				<u>XX</u>															

cream wet  
ingredients  
(Wet)

chill  
dough  
(Wet)

blend  
oatmeal  
(Dry)

wash  
dishes  
(Cleanup)

mix in eggs  
one by one  
(Wet)

add chocolate,  
nuts, &/or  
coconut  
(Flavor)

preheat  
oven  
(Bake)

mix in  
blended  
oatmeal  
(Dry)

mix dry  
ingredients  
(Dry)

roll into  
golf-balls  
(Bake)

grate milk  
chocolate  
(Flavor)

let cookies  
cool  
(Bake)

add dry to wet  
ingredients  
(Wet)

bake for 9-11  
minutes  
(Bake)

chop  
nuts  
(Flavor)

eat  
cookies  
(Cleanup)

