TOPIC
Mathematical Connections and Problem Solving

KEY QUESTION
How do you make a plan to get all food on the table at the same time for a large party dinner such as Thanksgiving for 18 people?

LEARNING GOALS
Students will:
• Use data to create a plan for cooking dinner and a method for making the plan for any dinner party
• Consider how to use and exclude data
• Make decisions about whether or not a solution meets the needs of a client
• Communicate the solution clearly to the client

GUIDING DOCUMENTS
• This activity has the potential to address many mathematics standards. Please see pages 5-6 for a complete list of mathematics and science standards.

RECOMMENDED SUPPLIES FOR ALL MODEL-ELICITING ACTIVITIES
It is recommended to have all of these supplies in a central location in the room. It is recommended to let the students know that they are available, but not to encourage them to use anything in particular.

• Overhead transparencies and transparency markers/pens, whiteboards and markers, or other presentation tools such as a document camera.
• Calculators
• Markers, colored pencils, pencils
• Construction paper, graph paper, lined paper
• Paper towels or tissues (for cleaning transparencies)
• Manila folders or paper clips for collecting the students’ work
• Optional: Computers with programs such as Microsoft Word and Excel

WHAT ARE MODEL-ELICITING ACTIVITIES (MEAs)?
Model-Eliciting Activities are problem activities explicitly designed to help students develop conceptual foundations for deeper and higher order ideas in mathematics, science, engineering, and other disciplines. Each task asks students to mathematically interpret a complex real-world situation and requires the formation of a mathematical description, procedure, or method for the purpose of making a decision for a realistic client. Because teams of students are producing a description, procedure, or method (instead of a one-word or one-number answer), students’ solutions to the task reveal explicitly how they are thinking about the given situation.

THE CATERING THANKSGIVING DINNER MEA ACTIVITY CONSISTS OF FOUR COMPONENTS:
1) Newspaper article: Students individually read the newspaper article to become familiar with the context of the problem. This handout is on page 7.
2) Readiness questions: Students individually answer these reading comprehension questions about the newspaper article to become even more familiar with the context and beginning thinking about the problem. This handout is on page 8.
3) Problem statement: In teams of three or four, students work on the problem statement for 45 – 90 minutes. This time range depends on the amount of self-reflection and revision you want the students to do. It can be shorter if you are looking for students’ first thoughts, and can be longer if you expect a polished solution and well-written letter. This handout is on page 9.
4) Process of sharing solutions: Each team writes their solution in a letter or memo to the client. Then, each team presents their solution to the class. Whole class discussion is intermingled with these presentations to discuss the different solutions, the mathematics
involved, and the effectiveness of the different solutions in meeting the needs of the client. In totality, each case study takes approximately 2-3 class periods to implement, but can be shortened by having students do the individual work during out-of-class time. The Presentation Form can be useful and is explained on page 4 and found on page 10.

**RECOMMENDED PROGRESSION OF THE CATERING THANKSGIVING DINNER MEA**

While other implementation options are possible for MEAs, it is recommended that the MEA be implemented in a cooperative learning format. Numerous research studies have proven cooperative learning to be effective at improving student achievement, understanding, and problem solving skills. In this method students will complete work individually (Newspaper article and readiness questions; as well as initial thoughts on the problem statement) and then work together as a group. This is important because brainstorming works best when students have individual time to think before working as a group. Students can be graded on both their individual and group contributions. Social skills’ discussion at the beginning of the MEA and reflection questions at the end of the MEA are also essential aspects of cooperative learning.

**Social Skills (3 -5 minutes)**
Students must be taught how to communicate and work well in groups. Several social skills that are essential to group work are decision-making, asking questions, and communicating and listening. The teacher can show part of a YouTube video and discuss aspects of these skills before beginning the MEA.
(http://www.youtube.com/user/flowmathematics)

**Newspaper Article and Readiness Questions:**
The purpose of the newspaper article and the readiness questions is to introduce the students to the context of the problem.

(10 minutes): Give the article and the questions to the students the day before for homework. Then, in the next class, discuss as a class the answers to the readiness questions before beginning to discuss the problem statement.

**Problem Statement:**
You may want to read the problem statement to the students and then identify as a class: a) the client that the students are working for and b) the product that the students are being asked to produce. Once you have addressed the points above, allow the students to work on the problem statement. Let the students know that they will be sharing their solution to the rest of the class. Tell students you that you will randomly pick a group member to present for each group. Tell the students that they need to make sure that everyone understands their group’s solution so they need to be sure to work together well. The group member who will present can be picked by assigning each group member a number.

**Working on the Problem Statement (35-50 minutes):** Place the students in teams of three or four. Students should begin to work by sharing their initial ideas for solving the problem. If you already use teams in your classroom, it is best if you continue with these same teams since results for MEAs are better when the students have already developed a working relationship with their team members. If you do not use teams in your classroom and classroom management is an issue, the teacher may form the teams. If classroom management is not an issue, the students may form their own teams. You may want to have the students choose a name for their team to promote unity.

**Teachers’ role:** As they work, your role should be one of a facilitator and observer. Avoid questions or comments that steer the students toward a particular solution.
to answer their questions with questions so that the student teams figure out their own issues. Also during this time, try to get a sense of how the students are solving the problem so that you can ask them questions about their solutions during their presentations.

Presentations of Solutions (15-30 minutes):
The teams present their solutions to the class. There are several options of how you do this. Doing this electronically or assigning students to give feedback as out-of-class work can lessen the time spent on presentations. If you choose to do this in class, which offers the chance for the richest discussions, the following are recommendations for implementation. Each presentation typically takes 3 – 5 minutes. You may want to limit the number of presentations to five or six or limit the number of presentations to the number of original (or significantly different) solutions to the MEA. Before beginning the presentations, encourage the other students to not only listen to the other teams’ presentations but also to a) try to understand the other teams’ solutions and b) consider how well these other solutions meet the needs of the client. You may want to offer points to students that ask ‘good’ questions of the other teams, or you may want students to complete a reflection page (explanation – page 4, form – page 11) in which they explain how they would revise their solution after hearing about the other solutions. As students offer their presentations and ask questions, whole class discussions should be intermixed with the presentations in order to address conflicts or differences in solutions. When the presentations are over, collect the student teams’ memos/letters, presentation overheads, and any other work you would like to look over or assess.

ASSESSMENT OF STUDENTS’ WORK
You can decide if you wish to evaluate the students’ work. If you decide to do so, you may find the following Assessment Guide Rubric helpful:

Performance Level Effectiveness: Does the solution meet the client’s needs?
Requires redirection: The product is on the wrong track. Working longer or harder with this approach will not work. The students may need additional feedback from the teacher.

Requires major extensions or refinements: The product is a good start toward meeting the client’s needs, but a lot more work is needed to respond to all of the issues.

Requires editing and revisions: The product is on a good track to be used. It still needs modifications, additions or refinements.

Useful for this specific data given, but not shareable and reusable OR Almost shareable and reusable but requires minor revisions: No changes will be needed to meet the immediate needs of the client for this set of data, but not generalized OR Small changes needed to meet the generalized needs of the client.

Share-able or re-usable: The tool not only works for the immediate solution, but it would be easy for others to modify and use in similar situations. OR The solution goes above and beyond meeting the immediate needs of the client.

IMPLEMENTING AN MEA WITH STUDENTS FOR THE FIRST TIME
You may want to let students know the following about MEAs:
• MEAs are longer problems; there are no immediate answers. Instead, students should expect to work on the problem and gradually revise their solution over a period of 45 minutes to an hour.
• MEAs often have more than one solution or one way of thinking about the problem.
• Let the students know ahead of time that they will be presenting their solutions to the class. Tell them to prepare for a 3-5 minute presentation, and that they may use overhead transparencies or other visuals during their presentation.
• Let the students know that you won’t be answering questions such as “Is this the right way to do it?” or “Are we done yet?” You can tell them that you will answer clarification questions, but that you will not guide them through the MEA.
• Remind students to make sure that they have returned to the problem statement to verify that they have fully answered the question.
• If students struggle with writing the letter, encourage them to read the letter out loud to each other. This usually helps them identify omissions and errors.

OBSERVING STUDENTS AS THEY WORK ON THE CATERING THANKSGIVING DINNER MEA
You may find the Observation Form (page 10) useful for making notes about one or more of your teams of students as they work on the MEA. We have found that the form could be filled out “real-time” as you observe the students working or sometime shortly after you observe the students. The form can be used to record observations about what concepts the students are using, how they are interacting as a team, how they are organizing the data, what tools they use, what revisions to their solutions they may make, and any other miscellaneous comments.

PRESENTATION FORM (Optional)
As the teams of students present their solutions to the class, you may find it helpful to have each student complete the presentation form on page 11. This form asks students to evaluate and provide feedback about the solutions of at least two teams. It also asks students to consider how they would revise their own solution to the Catering Thanksgiving Dinner MEA after hearing of the other teams’ solutions.

STUDENT REFLECTION FORM
You may find the Student Reflection Form (page 12) useful for concluding the MEA with the students. The form is a debriefing tool, and it asks students to consider the concepts that they used in solving the MEA and to consider how they would revise their previous solution after hearing of all the different solutions presented by the various teams. Students typically fill out this form after the team presentations.

STANDARDS ADDRESSED
NCTM MATHEMATICS STANDARDS
Algebra
• Represent, analyze, and generalize a variety of patterns with tables, graphs, words, and, when possible, symbolic rules
• Relate and compare different forms of representation for a relationship
• Model and solve contextualized problems using various representations, such as graphs, tables, and equations
• Use symbolic algebra to represent and explain mathematical relationships
• Identify essential quantitative relationships in a situation and determine the class or classes of functions that might model the relationships
• Draw reasonable conclusions about a situation being modeled
Measurement
• Analyze precision, accuracy, and approximate error in measurement situations
Problem Solving
• Build new mathematical knowledge through problem solving
• Solve problems that arise in mathematics and in other contexts
• Apply and adapt a variety of appropriate strategies to solve problems
• Monitor and reflect on the process of mathematical problem solving

Reasoning and Proof
• Develop and evaluate mathematical arguments and proofs

Communication
• Communicate their mathematical thinking coherently and clearly to peers, teachers, and others
• Analyze and evaluate the mathematical thinking and strategies of others

Connections
• Recognize and use connections among mathematical ideas
• Understand how mathematical ideas interconnect and build on one another to produce a coherent whole
• Recognize and apply mathematics in contexts outside of mathematics

Common Core Mathematics Standards

3.0.A.8 Solve two-step word problems using the four operations. Represent these problems using equations with a letter standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding

6.RP. Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, “The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak.” “For every vote candidate A received, candidate C received nearly three votes.”

7.RP Recognize and represent proportional relationships between quantities.
   a. Decide whether two quantities are in a proportional relationship, e.g., by testing for equivalent ratios in a table or graphing on a coordinate plane and observing whether the graph is a straight line through the origin.
   b. Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of proportional relationships.
   c. Represent proportional relationships by equations. For example, if total cost $t$ is proportional to the number $n$ of items purchased at a constant price $p$, the relationship between the total cost and the number of items can be expressed as $t = pn$.

Representation
• Use representations to model and interpret physical, social, and mathematical phenomena

NRC Science Standards
Inquiry
• Use appropriate tools and techniques to gather, analyze and interpret data
• Develop descriptions, explanations, predictions, and models using evidence
• Think critically and logically to make the relationships between evidence and explanations
• Recognize and analyze alternative explanations and predictions
• Communicate scientific procedures and explanations
• Use mathematics in all aspects of scientific inquiry
<table>
<thead>
<tr>
<th>Mathematical Practice</th>
<th>How it occurs in MEAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Make sense of problems and persevere in solving them.</td>
<td>As participants work through iterations of their models they continue to gain new insights into ways to use mathematics to develop their models. The structure of MEAs allows for participants to stay engaged and to have sustained problem solving experiences.</td>
</tr>
<tr>
<td>2. Reason abstractly and quantitatively</td>
<td>MEAs allow participants to both contextualize, by focusing on the real world context of the situation, and decontextualize by representing a situation symbolically.</td>
</tr>
<tr>
<td>3. Construct viable arguments and critique the reasoning of others.</td>
<td>Throughout MEAs while groups are working and presenting their models.</td>
</tr>
<tr>
<td>4. Model with mathematics.</td>
<td>This is the essential focus of MEAs; for participants to apply the mathematics that they know to solve problems in everyday life, society, or the workplace. This is done through iterative cycles of model construction, evaluation, and revision.</td>
</tr>
<tr>
<td>5. Use appropriate tools strategically.</td>
<td>Materials are made available for groups as they work on MEAs including graph paper, graphing calculators, computers, applets, dynamic software, spreadsheets, and measuring devices.</td>
</tr>
<tr>
<td>6. Attend to precision.</td>
<td>Precise communication is essential in MEAs and participants develop the ability to communicate their mathematical understanding through different representations including written, verbal, symbolic, graphical, pictorial, concrete, and realistic.</td>
</tr>
<tr>
<td>7. Look for and make use of structure.</td>
<td>Participants in MEAs can use their knowledge of mathematical properties and algebraic expressions to develop their solutions.</td>
</tr>
<tr>
<td>8. Look for and express regularity in repeated reasoning.</td>
<td>As participants develop their models the patterns they notice can assist in their model development.</td>
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</tbody>
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Thanksgiving Dinner for Today’s Busy Families

St. Paul, MN – American families have many Thanksgiving traditions. Gobble & Goodies Catering Service is helping families put all their favorite traditions on the table at Thanksgiving without all of the hassles. The Thompson family of Maplewood has decided to allow Gobble & Goodies to cater their Thanksgiving dinner. Mara Thompson has always wanted to enjoy spending time with her family, but has always spent most of Thanksgiving in the kitchen. This year, she has also just started a new job at the local bank. “This year, I just don’t have the time or energy before the big day to start getting ready for my 5 children, my parents, the in-laws, 7 grandchildren, and a few friends of the family that will come to my house. I wanted some time to enjoy the season.” There have been 20 to 30 people eating at their house for Thanksgiving dinner before. “It seems like I spend too much time preparing things on Thanksgiving Day. It’s just become an overwhelming task,” said Mrs. Thompson.

Gobble & Goodies Catering has received many requests for Thanksgiving dinner preparation from families just like the Thompsons. Many families these days are too busy in the days before the big dinner to shop and get things ready. Also, they would like to spend time doing fun things with each other rather than cooking in a hot kitchen. This upstart catering company has made things very simple and can help out on a variety of levels. They can provide everything for the whole meal hot and ready at your door on Thanksgiving Day or you can pick up dishes the day before to heat up yourself. They have a wide variety of dishes available including all the standard holiday favorites like mashed potatoes, stuffing, vegetables, pies and turkey. They also have some new items that your family might like to make a new holiday tradition including many vegetarian dishes and low-fat, low-cholesterol dishes for the health conscious.

Gobble & Goodies Catering also has cooks they can send to your home to take care of everything while you relax and visit with friends and family. “It takes a lot of planning and organization to make sure we can satisfy our customers, but making people happy is worth it,” said Jane Christie, owner.

Gobble & Goodies Caterers does catering service year round and is available for holiday parties, New Year’s Eve parties, and any other celebration where you might like a little help with the food. They can cater for 4 to 400 people. They also work with other local businesses like Eva’s Flowers and the Joanne’s Party and Gift so you can complete your event with flowers, decorations and other party needs.
Readiness Questions

1. How many people are expected to have dinner at the Thompson’s house?

2. Why did the Thompson family decide to use a catering service for Thanksgiving dinner?

3. What kinds of food does the catering service offer?

4. What other reasons might someone hire a catering service to bring in food?

5. What must you know in order to have several different dishes for a dinner ready to eat at the same time?
The Problem

Mrs. Thompson is trying to host about 18 people for her Thanksgiving Day dinner. Since she doesn’t have time to plan or prepare this year, she has hired the caterers to do the work. They will come to the house to cook everything, but they have some other dinners to prepare that day so they need to keep a tight schedule or they will be late for the next job. They will send 2 people to the house to fix dinner. **Gobble & Goodies has hired your team to construct a schedule and plan that will enable the caterers to finish all of the food by 2:20 so the Thompson’s can eat by 2:30.** The caterers will need to know when to arrive at her house and how to plan cooking each dish on the list. **However, even more importantly, Gobble & Goodies wants you to develop a method for her caterers to use for any cooking schedule that way the caterers can create a new plan for any other big dinner party.**

The table shows the dishes that need to be prepared, how many of each dish will be made, how long to prepare the dish, how the dish is cooked and how long it takes to cook. Note that some things don’t need to be cooked (for example fruit salad) so there is no cook time, just time for preparation. Also, some dishes need to be hot when they are served. Mrs. Thompson has two ovens, four burners on the stovetop, and a microwave.

<table>
<thead>
<tr>
<th>Dish</th>
<th>Number of batches</th>
<th>Time to Prepare each batch</th>
<th>How to Cook</th>
<th>Time to Cook</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turkey</td>
<td>1</td>
<td>30 minutes</td>
<td>Oven</td>
<td>4 hours</td>
</tr>
<tr>
<td>Ham</td>
<td>1</td>
<td>25 minutes</td>
<td>Oven</td>
<td>2 hours</td>
</tr>
<tr>
<td>Rolls</td>
<td>3 baking sheets</td>
<td>30 minutes</td>
<td>Oven</td>
<td>20 minutes</td>
</tr>
<tr>
<td>Mashed Potatoes</td>
<td>3 pots</td>
<td>40 minutes</td>
<td>Stovetop</td>
<td>45 minutes</td>
</tr>
<tr>
<td>Green Beans</td>
<td>2 baking dishes</td>
<td>15 minutes</td>
<td>Microwave</td>
<td>10 minutes</td>
</tr>
<tr>
<td>Cranberry Sauce</td>
<td>1 dish</td>
<td>25 minutes</td>
<td>None</td>
<td>----</td>
</tr>
<tr>
<td>Steamed Carrots</td>
<td>2 pans</td>
<td>20 minutes</td>
<td>Stovetop</td>
<td>30 minutes</td>
</tr>
<tr>
<td>Fruit Salad</td>
<td>2 bowls</td>
<td>45 minutes</td>
<td>None</td>
<td>----</td>
</tr>
<tr>
<td>Tossed Salad</td>
<td>2 bowls</td>
<td>30 minutes</td>
<td>None</td>
<td>----</td>
</tr>
<tr>
<td>Sweet Potatoes</td>
<td>1 baking dish</td>
<td>20 minutes</td>
<td>Oven</td>
<td>1 hour</td>
</tr>
<tr>
<td>Jello Salad</td>
<td>1 bowl</td>
<td>25 minutes</td>
<td>Refrigerate</td>
<td>2 hours</td>
</tr>
<tr>
<td>Gravy</td>
<td>1 pan</td>
<td>10 minutes</td>
<td>Stovetop</td>
<td>20 minutes</td>
</tr>
<tr>
<td>Turkey Stuffing</td>
<td>1 batch</td>
<td>20 minutes</td>
<td>Cook in Turkey</td>
<td>----</td>
</tr>
<tr>
<td>Extra Stuffing</td>
<td>1 baking dish</td>
<td>20 minutes</td>
<td>Oven</td>
<td>45 minutes</td>
</tr>
</tbody>
</table>
OBSERVATION FORM FOR TEACHERS - Catering Thanksgiving Dinner MEA

Team: ____________________________

STEM (Science, Technology, Engineering, & Mathematics) Concepts Used:
What STEM concepts and skills did the students use to solve the problem?

Team Interactions:
How did the students interact within their team or share insights with each other?

Data Organization & Problem Perspective:
How did the students organize the problem data? How did the students interpret the task? What perspective did they take?

Tools:
What tools did the students use? How did they use these tools?

Miscellaneous Comments about the team functionality or the problem:

Cycles of Assessment & Justification:
How did the students question their problem-solving processes and their results? How did they justify their assumptions and results? What cycles did they go through?
PRESENTATION FORM – Catering Thanksgiving Dinner MEA

Name_______________________________

While the presentations are happening, choose TWO teams to evaluate. Look for things that you like about their solution and/or things that you would change in their solution. You are not evaluating their style of presenting. For example, don’t write, “They should have organized their presentation better.” Evaluate their solution only.

Team _____________________________

What I liked about their solution:

What I didn’t like about their solution:

Team _____________________________

What I liked about their solution:

What I didn’t like about their solution:

After seeing the other presentations, how would you change your solution? If you would not change your solution, give reasons why your solution does not need changes.
STUDENT REFLECTION FORM – Catering Thanksgiving Dinner MEA

Name ___________________________ Date ______________________

1. What mathematical or scientific concepts and skills (e.g. ratios, proportions, forces, etc.) did you use to solve this problem?

2. How well did you understand the concepts you used?
   
   Not at all         A little bit       Some        Most of it       All of it

   Explain your choice:

3. How well did your team work together? How could you improve your teamwork?

4. Did this activity change how you think about mathematics?