TOPIC
Mathematical connections and Problem Solving

KEY QUESTION
How can groups use meteorologist instruments such as table, charts and maps to make weather forecasts?

LEARNING GOALS
Students will:
• Using different type of background information (e.g. newspaper articles and weather maps) and temperature bands to predicted the real weather map.
• Use numeric and visual aids to make the best accurate prediction.
• Make decisions about whether or not the processes of prediction can lead to the most accurate prediction and provide the best help for a client
• Communicate the solution clearly to the client

GUIDING DOCUMENTS
This activity has the potential to address many mathematics and science standards, as well as address engineering principles. Please see pages 4-6 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 or whiteboards and markers or other presentation tools such as a document camera.
• Calculators
• Rulers, scissors, tape
• 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 Meteorology Madness MEA 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. The handouts are on pages 9-13.

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 MEA 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 15.

**RECOMMENDED PROGRESSION OF THE Meteorology Madness 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. Try 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 6, form – page 16) 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.

**Shareable 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 Meteorology Madness MEA
You may find the Observation Form (page 14) 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 15. 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 Meteorology Madness MEA after hearing of the other teams’ solutions.

STUDENT REFLECTION FORM
You may find the Student Reflection Form (page 16) 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
Numbers and Operations:
- Understand and use ratios and proportions to represent quantitative relationships
- Understand the meaning and effects of arithmetic operations with fractions, decimals, and integers
- Judge the reasonableness of numerical computations and their results
Algebra
- Represent, analyze, and generalize a variety of patterns with tables, graphs, words, and, when possible, symbolic rules
- Model and solve contextualized problems using various representations, such as graphs, tables, and equations
- 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

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

Common Core Math Standards
6.NS.5. Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation.
6.NS.6. Understand a rational number as a point on the number line. Extend number line diagrams and coordinate axes familiar from previous grades to represent points on the line and in the plane with negative number coordinates.
   a. Recognize opposite signs of numbers as indicating locations on opposite sides of 0 on the number line; recognize that the opposite of the opposite of a number is the number itself, e.g., \(-(-3) = 3\), and that 0 is its own opposite.

   a. Interpret statements of inequality as statements about the relative position of two numbers on a number line diagram. For example, interpret \(-3 > -7\) as a statement that \(-3\) is located to the right of \(-7\) on a number line oriented from left to right.
   b. Write, interpret, and explain statements of order for rational numbers in real-world contexts. For example, write \(-3 \circ C > -7 \circ C\) to express the fact that \(-3 \circ C\) is warmer than \(-7 \circ C\).
   c. Understand the absolute value of a rational number as its distance from 0 on the number line; interpret absolute value as magnitude for a positive or negative quantity in a real-world situation. For example, for an account balance of \(-30\) dollars, write \(|-30| = 30\) to describe the size of the debt in dollars.

• 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

ABILITIES OF TECHNOLOGICAL DESIGN
• Identify appropriate problems for technological design.
• Design a solution or product.
• Evaluate completed technological designs or products.
• Communicate the process of technological design.

UNDERSTANDINGS ABOUT SCIENCE AND TECHNOLOGY
• Technological solutions have intended benefits and unintended consequences. Some consequences can be predicted, others cannot.
• Creativity, imagination, and a good knowledge base are all required in the work of science and engineering.
### Standards for Mathematical Practices

**Integration with MEAs**

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<thead>
<tr>
<th>Mathematical Practice</th>
<th>How it occurs in MEAs</th>
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<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>
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<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>
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<td>3. Construct viable arguments and critique the reasoning of others.</td>
<td>Throughout MEAs while groups are working and presenting their models.</td>
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<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>
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<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>
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<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>
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<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>
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<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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Meteorology Madness

Michigan City, IN-Students at Barker Middle School are experiencing meteorology madness in their science and math classes this quarter. Science teacher Bruce Starek and math teacher Jane Medley are investigating with their students the many weather phenomenon experienced in the Mid-West. These two experienced middle school teachers created this interdisciplinary unit after their students presented them with some good questions. Mr. Starek stated recently, “They asked how the local weather forecasters knew a snowstorm was on the way. As I did more investigating on weather forecasting, I realized it was a natural fit with math.”

The students have learned a great deal about weather forecasting. They have read a number of books, visited websites, watched the Weather Channel, and interviewed a local meteorologist. Jalica Brown, a sixth grader commented, “It’s so great to be able to learn something in school that is about real life.”

Nicole Brown, a meteorologist from Channel 16 in South Bend, came to the class. She explained what she does to create a forecast. “We read a variety of instruments, look at different weather patterns throughout the country, and use some weather models to create a forecast.” There are five different weather models that are widely accepted and used by meteorologists. Different forecasts can be generated depending on which model is used. It is not an exact science, but an educated guess. Many meteorologists often will use more than one model and then share their different findings as they make their forecasts. “It now makes sense why sometimes the forecaster says that the weather will be one way for one model and another way for a different model,” noted Tanisha Williams.

One of the main points that the students have learned is that even using the right model and having accurate information from the instruments will not always mean the prediction is 100% accurate. Weather is something that can change quickly and unexpectedly.

The students have learned about the wide variety of weather instruments, and what these tell the meteorologist. They have also made these instruments and set up their own weather station at the school. Each day a set of students will read the instruments and check each other’s readings. They then use their readings to create tables, charts, and maps. Students use this information to make weather forecasts, which are broadcast on the local cable channel. They also send their information to the weather team at Channel 16. They will often use this in their nightly reports. In fact, this project has inspired other teachers to do similar units at their schools. Weather stations at local schools are popping up all over northern Indiana.
Meteorology Readiness Questions

Answer these questions after reading the article and studying the typical weather map of the United States provided in the article.

1) What is meteorology?

2) Why is the unit on meteorology a good fit between math and science?

3) What do the different colors on the map represent?

4) Approximately what temperature is it in the regions that are in the dark blue temperature band (in both Celsius and Fahrenheit)?

5) Do the colored bands on the map tell what temperature it is in that region at 9 a.m., 12 p.m., and 5 p.m. that day?

6) Is every place of the same color the exact same temperature?

7) Approximately how much would the increase or decrease in the temperature be for a region that went from being in the bright yellow band today to being in the bright blue band tomorrow?

8) What do you need to do to make a prediction?

9) Why are weather predictions not always accurate?

10) What things affect weather?
Meteorology Warm – Up Activity

Look at the 4 weather maps on the following page to answer the following question:

Question: Given the four weather maps provided, predict what the fifth day’s weather map will look like?
Weather Maps

Day 1

Day 2

Day 3

Day 4

Weather Map Legend

© 2010 University of Minnesota
Blank Map of the United States for Prediction
Meteorology Problem

Your class has been asked by a local meteorologist to help with the local weather forecasts. To be sure that you are ready to do this task, the meteorologist has given you a task. Correctly completing the task with a thorough explanation will help the meteorologist know you are able to help in weather forecasting.

Every team of students has been given the four weather maps provided for the warm-up activity. Each team has created a prediction for what the fifth day’s weather map will look like. Now, each team of students is to do three things. First, your team needs to decide which of the mustard yellow temperature bands on the predicted weather maps is the most accurate prediction of the mustard yellow temperature band on the real weather map for the fifth day. Second, determine which predicted weather map, overall, best predicted the real weather map for day 5. Use the prior 4 days’ weather maps to help you make these decisions. Third, you need to write a detailed explanation for why the predicted weather map is the most accurate weather map. The meteorologist will use these explanations to make a decision about which students will help with weather predictions.
OBSERVATION FORM FOR TEACHER - Meteorology Madness 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 – Meteorology Madness 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 – Meteorology Madness 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?