The 'Bama Bears Challenge: Launching into Engineering Design

A Middle School Launcher

from **Engaging Youth through Engineering**

(EYE) 2013

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EYE Launcher: Introducing Engineering Design

A two-part lesson that frames the year’s EYE engineering experience.

Overview

The Launcher lessons introduce the new middle school student to an engineering classroom. Over the course of two class sessions (one in science and one in math) students engage in a brief, yet appealing design challenge. This design challenge serves a number of purposes – first, to launch the engineering program for the school year; secondly, to introduce students to the mindset of an engineer and the way engineers themselves tackle and solve problems. In addition, students become aware of and discuss the importance of collaboration and effective teamwork skills to a design team.

Learning Objectives

- Relate an 8-step Engineering Design Process model to their own actions and experiences while solving an engineering problem.
- Relate the 8-step Engineering Design Process (EDP) to the Engineering is Elementary 5-step Engineering Design Process (if applicable).
- Provide examples of math and science connections to the design challenge, based on their own experiences.
- Explain how teamwork can be an important part of a successful EDP.
- Recognize and practice target middle school teamwork behaviors – active contributing & active listening.

Science

Lesson S-1: Launch the Mini-design Challenge

Overview

Students begin this lesson with a discussion about engineers and what engineers do – create technologies. In this case, the technology that the students observe and discuss is a roll of tape. Next, students will engage in a short, low risk, high interest design challenge to launch them into the mindset of an engineer and an engineering classroom. In the context of helping to prominently display a team mascot, students will design, create, and test towers to support a small stuffed teddy bear.

Materials for This Lesson

For the Whole Class (up to 32 students)

- ☐ Box, small; 1
- ☐ Teddy bears, identical; 4

For each group/Team of 4 Students

- ☐ Index Cards; 50
- ☐ Tape (cellophane or masking); 1 roll

For each student

- ☐ Index Card; 1

Preparation (10 min.)

1. For each student group, organize the materials for easy handout.

2. Place the cellophane tape inside the box. Place the box where you can have ready access and all students can see it.

3. Place the teddy bears out of view but within easy reach.

4. Plan to have students work in groups of 4. Arrange desks accordingly.

Procedures (45 min.)

Set the stage for an engineering classroom. (10 min.)

1. Tell students that throughout their middle school experience, they will have several opportunities to participate in different engineering challenges. Ask students if they know anything about engineering or what engineers do. Accept all answers. Explain that engineers work to develop and improve technology.

2. Ask students what they think of when they hear the word, technology. Accept all answers.

3. Show students the box and tell them that there is a piece of technology inside. Ask them to suggest what that technology might be. Responses typically include any item related to electronics.

4. Reveal the technology (the cellophane tape). Explain that technology includes everyday objects. Stress that a technology is anything that people create to solve a problem. **Ask:**

   What problem does this technology solve?

   It fastens or sticks things together.

5. Ask students to look around the room. **Ask:**

   What other technologies do you see and what problems do they solve?

6. Remind students that engineers are behind the creation of most of these technologies. Someone had to think about how to design, or create these.

7. Tell students that over the next two sessions, students will be engineers and do what engineers do: work and collaborate in teams to design solutions to problems. They will be encouraged to think creatively.

8. Explain that engineers know there is no one correct idea to solve a problem - it is important to consider many ideas. Stress that good teamwork will be extremely important for the success of any design.

9. Advise students that they should be thinking about what contributes to good teamwork throughout this lesson.

Present the design challenge and establish design criteria and constraints. (10 min.)

10. Present this scenario

The brand new pro-football team, the 'Bama Bears, is about to finish construction on its brand new stadium - right here in Mobile, Alabama! The team owners have heard that this school has a lot of student engineers, and have come to you and the rest of our grade for help with a problem.

The company working on the stadium forgot about displaying the mascot! In two days, the first exhibition game will be played and this is what the mascot will look like on the sidelines:

Place one of the teddy bears on the floor, noting that the bear is not very well displayed. *Tell students that this is the problem that the team owners want the class to fix.* **Say:**

Our task as a class is to figure out, construct, and test possible designs for a tower that will prominently display the mascot, so that people can see and enjoy it during the games. We have to do this before the first game.

Hold up the bear so students can see it better.

11. Tell students that typically engineers have a lot of questions when they are first faced with a design challenge. Invite students to ask any questions they may have about this challenge.

12. Record all questions before moving on to Step 13 (answering those questions). **Ask:**

    What do think you need to know before you begin to design a tower?

    Typically, students new to this kind of activity may be slow or shy about suggesting questions, but the momentum usually picks up if you provide adequate wait time (a slow count to 8, for example). Student questions include:

    How much time do we have? What does the tower have to look like? How tall does it need to be? How will we know it's a good tower? What materials can we use?

    As questions begin to be offered, be explicit that you will collect a list of questions first and then start to answer them.

    As a last resort: If you count to 8 to yourself and questions are not coming, you might prompt students with a comment such as, "Well, one thing engineers like to know about is materials. What questions do you have about materials for this challenge?" You only need a few questions to get started.

13. Answer student questions:
    - Students have 8 minutes to design and create their towers.
    - Every group will get the same materials; those materials will be 50 index cards, 1 roll of tape, and one pair of scissors.
    - The teddy needs to be supported by the tower without falling, for 10 seconds.

14. Tell students that questions they asked about what the tower must be able to do are called criteria. Questions that asked what students couldn't do or couldn't use are called constraints. All engineering design challenges contain criteria and constraints.

Allow time for student teams to design and create their towers. (10 min.)

15. Ready students for action. Distribute the index cards, tape, and scissors to each group. Tell students they have 8 minutes to design a tower that will hold the teddy bear for at least 10 seconds.

16. Circulate among teams as they work independently on their own solutions. While you may wish to provide encouragement, avoid giving direct instructions or correcting any mistakes or missteps you may see.

Also avoid fostering a competitive attitude. What is most important is that teams contend with their own ideas and processes.

17. At the 8 minute mark instruct all teams to stop working.

Help students test their towers, observe each other's tests, and discuss their results. (15 min.)

18. Instruct students to stand in a circle around their work tables in a way that all students can see every tower. Prompt students to examine each tower carefully.

19. Ask questions to elicit student observations and reaction.

    Are these towers all the same? What is the same about them? What is different? Are there any towers that you think will definitely meet the criteria? Why?

20. Have half the student teams (4 teams) test their tower designs at the same time, while the remaining teams observe the tests. Encourage students to watch during the tests to observe which towers remain standing with the teddy on top, which ones wobble and sway, and which ones have at least partially collapsed.

    For the test, call a 3-2-1 countdown. At "1", one student from each team should set the teddy bear on his or her team's tower.

    Then time (or count) ten seconds for the test

21. Quickly debrief the results. **Ask:**

    What are some characteristics you might have noticed of towers that are successful? What can we learn from those towers that didn't work so well?

    Emphasize that in engineering, engineers often learn more from what doesn't work so well than they do from very successful designs. Both are important in engineering.

22. Repeat this testing and sharing with the other half of the class.

23. Summarize for the class the main points that arose during testing and discussion.

24. Ask students to think about one important improvement or change they could offer for a redesign.

25. Give every student an index card. Tell students that they will have a chance to design towers again in their math classrooms. Instruct every student to record one important idea about designing a tower to hold the teddy bear that he or she wants to remember.

26. Remind students that engineers often work together in teams. Ask students to quickly analyze how effectively their team worked by a show of thumbs up or thumbs down. Instruct students to identify one important skill that they think is necessary for a team to work well together and write that skill - a teamwork tip - on the flip side of the index card.

27. Tell students that it is imperative for them to bring their index cards to math class. This index card is their “ticket” to another attempt at a design for a tower.

28. Encourage students to be thinking about this tower challenge between now and when they return to this challenge in math class.

Math

LESSON M-1: Refocus on Teamwork, Redesign and Reflect on Engineering

Maintaining a focus on teamwork, students complete the mini-design challenge and reflect on their experiences in terms of the Engineering Design Process.

Overview

Applying information and insights from their first top design, student pairs redesign, create, and test a tower to hold a small teddy bear. Students identify and practice teamwork behaviors that will be highlighted throughout the school year. Students also reflect on their own problem-solving process and connect that to the eight steps of the EYE Engineering Design Process.

Materials for This Lesson

TEACHER RESOURCES

- ☐ PowerPoint Presentations: Engineering Design Process Slides (5 plus 8 steps) or Engineering Design Process Slides (8 steps only). Filename: EDP.slides.5and8steps or EDP.slides.8steps (available at http://www.eyemiddlegrades.wikispaces.com)
    - Alternative to slides: Engineering Design Process Cards; see Reproducible Resources, below.)

REPRODUCIBLE RESOURCES

- ☐ Active Listening and Active Contributing Cards; 1 set
- ☐ Engineering Design Process Cards; 1 set (optional, in lieu of PowerPoint Slides)

AV AND COMPUTER EQUIPMENT

- ☐ LCD Projector

All Other Materials

For the Whole Class (up to 32 students)

- ☐ Teddy bears, small, identical; 4

For each Pair of Students

- ☐ Index cards; 50
- ☐ Scissors; 1
- ☐ Tape (cellophane or masking); 12 inches

For each student

- ☐ Index card with notes about teamwork and design ideas, from S-1

Preparation (15 min.)

Prepare the materials.

1. Place materials in the paper bag for student pairs.

2. Plan to have students begin the class in groups of 4. Arrange seating so that you will have groups of 4.

3. Set up your computer and projection equipment so you can show the Engineering Design Process PowerPoint Presentation (if you choose not to use the cards).

4. Preview the two PowerPoint presentation files, Engineering Design Process Slides (5 plus 8 steps) and Engineering Design Process slides (8 steps only) and decide which of the two you will use based on your students' prior experiences. To help decide, consider the following:

   - Engineering Design Process Slides (5 plus 8 steps):
     - Includes a 5-step version of the EDP as well as the 8-step version used in EYE materials. (The 5 steps are: Ask, Imagine, Plan, Create, Improve).
     - If students have had significant experience with the *Engineering is Elementary* (EiE) program, they will be aware of this 5-step version of the EDP.
     - Intended to help students see the connection between their prior learning and the more detailed process they will learn and use.
   - Engineering Design Process Slides (8 steps only):
     - Includes only the 8-step EYE version of the EDP.
     - More appropriate for students who have not had significant experience with the EiE program.

5. Post the two cards, Active Listening and Active Contributing, on the board. Leave room under each card to post the teamwork behavior cards.

Procedures (45 min.)

Focus on the featured teamwork behaviors. (10 min.)

1. As students enter class, ask them to take a seat and pull out the index cards that they completed at the end of the previous day's science class. (Because the seats are pre-arranged, students will be in teams once they have taken their seats.)

2. Introduce the lesson by referring to the tower design challenge from Day 1, science class. During that class, students were asked to think about teamwork and the skills that are important for good teamwork. Tell them that teamwork is an important part of engineering, and that as they progress through middle school, they will tackle engineering challenges in teams. Tell them that the focus for middle school grade teamwork will be on active listening and active contributing (refer to the cards posted on the board).

3. Tell students that today they will work in new teams to improve a design for a tower. Present the teamwork behaviors and place the behavior cards on the board under the appropriate heading (active listening or active contributing).

4. Remind students that in science, they identified one skill important to teamwork and noted that skill on the index cards they brought to class. **Ask:**

   Did anyone write a teamwork tip on their index card that is similar to what is on the board?

   What was that tip? Which of the posted skills and behaviors do you see it connecting to?

5. Instruct students that they should keep these behaviors in mind and practice them as they continue with their tower design challenge. Tell the students that when you are learning a new set of skills, it's helpful to focus on just one piece of the set. Select one behavior from active listening and one behavior from active contributing that you will try especially hard to practice during today's lesson.

Set the stage for a second round of design. (10 min.)

6. Review the details of the engineering design challenge with the class (design a tower to hold the teddy to a count of 10 seconds.)

7. Tell students that engineers often have the opportunity to try out ideas and then redesign. When engineers redesign, they are often trying to improve the technology that they are working on. Tell students that in this session, they will have a chance to think about their past designs and work in new design teams to improve the towers.

8. Preview, and then facilitate, group members sharing ideas, focusing on contributing and listening:

   Point out to students that each person in a team always has something to contribute to that team, and that it is important for other group members to listen carefully for those contributions. Tell students that you will lead them through a conversation with their teams. This conversation will help their group benefit from what students learned the first time they tried this challenge and will also help them generate new ideas.

9. Tell students that groups will have four minutes to share ideas they captured from their first design attempt (each student wrote an idea on his or her index card in science class). Each student should take one minute to contribute his/her idea to the rest of the group. Each of the other three students should listen and then ask follow-up questions. Students who are listening should avoid saying whether or not they like the idea; instead they should simply ask questions to be sure they understand the idea. When a new student shares his or her idea, the group should try to find ways that these ideas are similar or different to those that came before (but not whether one is favored over the other). Stress that there will be time for forming opinions about which ideas to include in a design after this opportunity to share and explore ideas.

   Keep time and announce to students when it is time to change speakers.

10. Tell the class that you asked students to think and share in groups of four because it can be helpful to gather lots of ideas from different people. Also explain that you are now going to divide the groups into smaller design teams. Separate the groups of 4 students into pairs of students. Each pair is now a design team.

FYI

This is an important step. The purpose of dividing the groups into smaller teams is to allow all students an opportunity to have an active voice in decision-making during redesign.

11. Tell students that each pair will now have 8 minutes to redesign a tower. Remind them of the criteria: the tower must hold the teddy for at least 10 seconds. Distribute the materials to each student pair. When all student pairs have their materials, tell the class to begin work. After 8 minutes, call time and instruct students to immediately stand in a circle around their work tables in a way that all students can see every tower. Prompt students to examine each tower carefully. **Ask:**

    Are these towers the same as what you observed in science class?

    What is the same about them?

    Are there any differences from the first set of towers that you observed?

12. Have half the student teams (4 teams; 1 per teddy bear) test their tower designs at the same time, while the remaining half observes the tests. To do this, call a 3-2-1 countdown to when it is time for a student from each team to place the bear on the team's tower. Then time ten seconds and encourage students to observe which towers remain standing with the teddy on top, which ones wobble and sway, and which ones have at least partially collapsed. **Ask:**

    What changes seemed to make a difference in the success of the towers?

    What changes did not make much of a difference?

13. Repeat this testing and sharing with the other half of the class.

14. When all groups have tested, **Ask:**

    Do you think there was improvement from their first tower design?

    If so, what was the improvement?

    What was still challenging about this design?

    Can anyone begin to identify the essential features of a good tower?

15. Congratulate all and have students set the materials aside where they cannot be a distraction.

Present the 8 steps of the Engineering Design Process (EDP). (10 min.)

16. Frame the engineering design process discussion. Remind students that in the prior day's science class and now in today's math class, they

have been engineers. Tell students you would like them to generate a list of words that describes engineering.

17. Ask students to describe their activities throughout the challenge. Prompt students to use action words (verbs) as they share. Record responses. Typical responses include, think, share, ask, choose, build, test, discuss, work, communicate, etc.

18. Explain to students that these are the same types of actions that engineers take when they want to solve a problem. These actions are often organized into a process to help guide them as they make progress. This process is called the Engineering Design Process.

19. Begin to create the EDP graphic using either the slides you have or the EDP cards. (See Preparation Step 4 to help determine which version of the slides you will use.) Connect the students' work during the tower challenge to the steps of the EDP.

    Tell the students:

    Engineers begin with a goal in mind. In science class, you began with a goal. In this case, the goal was to design a technology – a tower to hold a teddy bear.

    Place the card, ***Goal,*** in the center of the board. **Ask:**

    The goal was narrowed down to a specific problem, or challenge, you had to solve. What was the problem?

    Design a tower from index cards that would hold a teddy bear to the count of 10 seconds.

    Place the card, ***Define the Problem***, on the board. Explain to students that this step is where they first began with this design challenge. They were challenged to build a tower that could hold the teddy bear for 10 seconds. **Ask:**

    What did you do after you were given this problem? *We asked questions.*

    Place the card, ***Research***, on the board. Explain to students that by asking questions about the tower design, they were doing research about the towers and the teddy bear the tower was supposed to support. Ask:

Your students may have had significant experience with the Engineering is Elementary program's 5-step version of the Engineering Design Process. If so, refer to those five steps (Ask, Imagine, Plan, Create, Improve) as you introduce their counterparts in the 8-step challenge.

Ask *corresponds to Define the Problem and Research.*

Imagine *corresponds to Develop Multiple Solutions.*

Plan *corresponds somewhat to choose.*

Create *also corresponds to Create a Prototype, along with Test and Evaluate.*

Improve *corresponds to Redesign.*

(There is no 5-step part of the Engineering Design Process that correlates to Communicate.)

EDP: 5 and 8 steps

EDP: 8 steps only

After you asked questions and were given answers about towers, you spent some time looking at materials. What did you discuss in your groups? *We discussed different ideas we had for designing towers.*

Place the card, ***Develop Multiple Possible Solutions***, on the board. Explain to students that, again, they were naturally following the Engineering Design Process – they were talking about and developing possible solutions to the tower challenge. **Ask:**

What did your team do after you discussed different ideas? *We decided on one of the ideas.*

Place the card, ***Choose***, on the board. Connect the students' work with this step of the EDP. **Ask:**

What did your team do once you chose an idea? *We built the tower.*

Place the card, ***Create a Prototype***, on the board. Connect the students' work with this step of the EDP. Explain that when engineers want to create something they often use a small, working model that they can test first. This is a prototype. In this sense, the paper towers can be thought of as prototypes of real-world towers. **Ask:**

What did you do after the teams created their towers? *We tested them and talked about our results.*

Place the card, ***Test & Evaluate***, on the board. Remind students that they tested their design and talked about the results of their tests. They asked, "What worked? What didn't?" **Ask:**

In today's class, after we talked about teamwork, what conversation did your team of 4 have? *We shared and discussed ideas we had from out original tower design.*

Place the card**, *Communicate***, on the board. Explain to students that they were communicating important ideas to one another about designing tops. **Ask:**

What did you do next? *Pairs of students planned and created another tower.*

Place the card, ***Redesign***, on the board. Connect students' work with this step of the EDP.

Reinforce the idea that the EDP is a logical path engineers follow to solve problems and that students moved through this same path easily

and naturally. Suggest to students that this path or process is not only a natural one, but a very important one as well. Also tell students that although this helps to organize problem-solving, engineers don't always follow these steps, or stages, in order. **Ask:**

Does anyone have an example of a time in this challenge when you went out of order with the steps?

Responses might include: We changed our minds once we started building; we had new ideas and added them; we pressed on our tower as we worked to see if it would work.

Affirm that this is part of the design process, too. Tell students that they will make use of this Engineering Design Process each time they tackle a design challenge.

Reflect on teamwork and team behaviors. (5 min.)

20. Invite students to reflect on their team activities and interactions during the design challenge. Ask students to identify teamwork behaviors they observed which supported active listening and active contributing. Invite a few students to share their observations. **Ask:**

    How do you think teamwork skills such as active listening and active contributing can help engineers when they are trying to solve a problem?

    You were engineers; how did these skills help you?

21. Remind students that each of them decided on one listening and one contributing behavior to focus on and practice. Ask all students to take a bit of time now to think about how well they practiced those skills.

Discuss math and science connections. (5 min.)

22. Explain to students that engineers use math and science as they solve design problems. Invite students to share any math and/or science skills they used while designing a tower. Responses might include: measurement, thinking about height, weight, balance, 3 dimensional shapes, observation, prediction, solving problems.

23. Explain to students that because math and science are so related to engineering, students will have opportunities to return to engineering challenges in both math and science classes throughout the year (and the rest of middle school). The engineering challenges will connect to the math and science they will be learning, just as it does for professional engineers. Encourage students to keep all of their experiences from this engineering challenge in mind as they embark on this new study of engineering design.

‘Bama Bears Challenge Reproducible Resources

Goal

Define the Problem

Research

Develop Multiple Solutions

Choose

Create a Prototype

Test and Evaluate

Communicate

Redesign

Active Listening

L1. Show it so they know it.

DO: Make eye contact.

AVOID: Making faces.

L2. Hear people out.

DO: Let people finish their sentences.

AVOID: Interrupting.

L3. Invite explanations.

DO: Ask a question to get someone to say more.

AVOID: Shutting down because you think you don't like an idea.

L4. Build on others' ideas.

DO: Say whose ideas you are building on.

AVOID: saying things like, "Oh, but I have a better idea."

L5. Check in to see if people agree.

DO: Ask – "Are we ready?"

AVOID: Beginning without the team.

Active Contributing

C1. Focus on the task at hand.

DO: Follow instructions correctly.

AVOID: Setting off on your own.

C2. Take turns.

DO: Share and help.

AVOID: Hogging materials or hogging time for sharing ideas.

C3. Stay positive.

DO: Say what's going well.

AVOID: Saying ideas are "bad" or "dumb."

C4. Be dependable.

DO: What you say you will.

AVOID: Being late or unprepared.

C5. Stay tuned to what's happening.

DO: Invite others by name to share.

AVOID: Talking to just one or two people.