

Development of Engineering Focused Lesson Plans for K8 Teachers and Students

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Introduction

While the entire population continually benefits from the work of engineering professionals, there are still relatively few graduating high school seniors electing to pursue a bachelor's degree in engineering. The fact that an engineering degree is not widely considered by entering freshmen is not a new development. However, it is becoming a more serious problem as the number of engineering graduates is failing to keep pace with demand. Most individuals involved in engineering outreach efforts agree that it is important to capture the attention of a child at an early age. If children are unaware of a profession, they cannot explore that occupation through play and personal discovery. That profession then goes unrecognized until it is too late; the now young adult has already placed personal boundaries on their professional future.

Several initiatives have been proposed and implemented in order to affect a child's awareness of engineering. In fact, the author was instrumental in the creation of a series of age appropriate videotapes focused specifically on Civil Engineering. These tapes have been widely disseminated and well received. While positive feedback continues to be received it has become apparent that there remains a need for other educational resources. These resources can be used in the K8 classroom, at a Career Day presentation, as a Boy/Girl Scout activity, and the like. Given this feedback, the decision was made to create a selection of lesson plans, again, age appropriate and focused on Civil Engineering.

One motivating factor for creating these lesson plans was a need to provide the end user a selection of self-contained educational units which introduce children, and young adults, to the profession of Civil Engineering. Forty-five lesson plans have been created where each lesson utilizes only readily available materials, each requires little or no cost for materials, and all lessons are packaged on one compact disk. Included on the disk are copies of the three original videotapes mentioned above. While this package focuses on Civil Engineering, it should be considered a model for introducing any engineering discipline to a child or young adult.

Criteria for Creating a Lesson Plan

As mentioned above, forty-five lesson plans have been created and packaged on a single compact disk. The lesson plans are separated into three grade levels: K to 2th grade, 3rd to 5th grade, and 6th to 8th grade, and five Civil Engineering sub-disciplines: geotechnical, environmental, structural, surveying, and transportation. There are three lessons for each combination of grade level and sub-discipline, or $3 \times 3 \times 5 = 45$. Each lesson plan has been saved

in Adobe's ® PDF format allowing for its use with either a Windows ® or Mac ® based computer.

Several content and format criteria were established prior to the development of any lesson plan (1). The most significant of these are highlighted below along with a few explanatory remarks.

1. Each lesson plan must be age appropriate.
It was determined early on that the lesson plans would be separated into three grade levels ranging from kindergarten to 8th grade. Obviously, an activity for a kindergartener would not be appropriate for an 8th grader, and vice versa. Thus, a certified educator experienced in early childhood development was brought on board to aid in the development of the lessons. State curricular requirements for each grade level were incorporated into the lesson plans.
2. Each lesson plan must be technically sound.
In addition to being age appropriate, the lessons must accurately present bona fide engineering concepts and principles. This criterion was satisfied via the author's professional background and the expertise of an engineering colleague.
3. Materials needed for a lesson must be readily available and inexpensive.
It is expected that elementary and middle school teachers will represent a significant portion of the audience for the lesson plans. Given the limited resources available to these educators, it was necessary to minimize the financial cost of implementing a lesson. Further, it was deemed important that an educator not be swayed from trying a lesson due to the costs associated with obtaining needed supplies. Thus, every effort was made to eliminate the financial barriers to implementation.
4. A lesson plan must be self contained.
In keeping with the premise that a lesson plan will not present barriers to its own use, a lesson must provide all the information needed to conduct, and assess, the activity. To this end, still images have been included with several lessons as an aid to the presenter. These images help to demonstrate and clarify steps involved in a project. Further, by responding to a few questions, the instructor can document the benefits and challenges of a lesson.
5. Whenever possible, supporting materials should be included with the lesson plans.
In addition to the lesson plans, the compact disk contains a list of grade appropriate books which can be referenced by the teacher. Also included are vocabulary lists for each grade level. Further, a library of relevant images (in jpg format) is provided. These resources extend the usefulness of the lesson plans to other aspects of the educational process, such as reading and spelling.
6. The lesson plans and related resources must be easily accessible.
The quality of the lesson plans would be a moot point if the intended audience could not gain access to the material. In order to make the lessons easy to use, each document was saved in Adobe ® PDT format on a single compact disk. Further, a web-style interface was created allowing for point-and-click access to any document.

Anatomy of a Lesson Plan

The layout used for the lesson plans was selected so that educators would be familiar and comfortable with the format. Moreover, the layout is such that any parent, scout troop leader, or practicing professional can easily implement an activity. A typical lesson is separated into the following sections: Overview, Objectives, Materials, Vocabulary List (when provided), Activity, Assessment, and Images (when provided). A sample lesson plan is presented, and examined, below. The lesson "Sponge Beam Square Shaped" was written for children in grades 3 to 5 and relates to structural engineering.

It must be noted that the sample lesson plan refers to several figures. Due to file size limitations, these images could not be included as a part of this paper. However, these images are provided with the lesson plan when printed from the compact disk.

The Overview section provides a brief introduction to the lesson. The purpose of this introduction is to explain the engineering principle that is demonstrated by the lesson. This section is important since elementary school teachers may not be sufficiently familiar with a concept and thus may not feel comfortable, at least initially, in presenting a lesson. In the example presented, the concepts of a beam, column, tension, and compression are explained.

In most cases, the Objectives, Vocabulary List, and Assessment sections will be of greater importance to the educator than to a parent, troop leader, or practicing engineering. These are the sections which aid a teacher in meeting the state's curriculum requirements.

The Activity and Images sections provide the step-by-step instructions to complete an activity. The images are meant to clarify specific steps in the procedure. Questions which might be raised by the students during the activity are also provided, along with an answer and explanation. Those familiar with the engineering concept can expand upon the activity and questions, should they wish to. Moreover, a given activity may spark the imagination of the teacher, resulting in enhancements to the basic lesson plan.

The Assessment section asks the teacher to comment on the success of the lesson and to make notes regarding a future use of the lesson. The assessment also seeks to document feedback from the students, including their ability to understand the concepts presented. Judging the student's understanding of a lesson can be achieved through a homework assignment, small scale project, or questions on an examination. When the venue is a career day or scout function, understanding can be assessed through a wrap-up question and answer session lead by the presenter.

It is hoped that through repeated use of a lesson, the instructor will develop ownership in the lesson, which will ultimately lead to improvements in the lesson and confidence in the instructor. This will then translate to excitement and greater understanding on behalf of the student.

SPONGE BEAM SQUARE SHAPED

3-5 STRUCTURES

Lesson 2

OVERVIEW

With respect to a building, a **beam** is a horizontal structural element that connects two **columns**, which are vertical members. In a bridge, beams connect successive pier supports. Beams in a bridge are often called "girders".

When a group of vertical columns is put together and connected with a group of horizontal beams, a building frame is created. A building frame looks something like a jungle gym. The beams are supported by the columns. The floor is supported by the beams. The weight of people, furniture, and equipment is supported by the floor.

In a framed building the loads placed on the floors cause the beams to bend. The columns are then compressed by the beams. The frames of buildings work together because the loads on the buildings develop compression in the columns and both **compression** and **tension** in the beams. When a material is bent, both compression and tension occur.

Thus, beams are a very important part of a building or bridge structure. Without them it would be much more difficult and costly to build floors, ceilings, and bridge decks.

OBJECTIVES

1. Students will discover how a beam resists the forces of people, furniture, equipment, or vehicles.
2. Students will observe how tension and compression forces develop within a beam.
3. Students will learn the meaning of several new vocabulary words.

MATERIALS

- Sponges -a common cleaning sponge, 1 per student
- Markers
- Ruler
- Books or blocks

VOCABULARY LIST

- beam, column, horizontal, vertical, neutral axis, cantilever, load, compression, tension, stiff materials, steel, concrete, wood

ACTIVITY #1

1. Begin by discussing the role of a beam in a structure, such as a building or house.
2. Refer to Figure 1. Take a plastic ruler and place it on two books which are set a few inches apart. Have the students observe what happens to the ruler as you push down on the center of the ruler. They will notice that the ruler moves at its ends and bends slightly. This illustrates how a beam reacts when it has a force applied to it.
3. Recall with the students the terms compression and tension. Ask them which one applies to the ruler. Was the ruler experiencing compression or tension when you applied load to it? The answer is both. There is tension along the underside of the ruler and compression along the top.
4. Hand out a sponge and marker to each student.
5. Refer to Figure 2. Have the students draw a set of evenly spaced, vertical lines on one of the narrow sides of the sponge.
6. Refer to Figure 3. Have the students hold the sponge along its short sides. Have them bend the sponge to create a humped shape. While bending the sponge, have the students observe what happens to the lines on the side.
7. Again, review the terms compression and tension. Remind the students that compression shortens the distance from end to end, and tension lengthens the distance from end to end.
8. Have the students identify the part of the sponge that is in tension and the part that is in compression. Like the ruler, the bottom is in tension and the top is in compression.
Next, have the students draw a horizontal line which is perpendicular to their vertical lines, and that is located at the mid-thickness of the sponge.
9. Have the students bend the beam a second time, again forming a hump.
10. At the level of the horizontal lines, examine what happened to the distance between the vertical lines. Answer: there is no change in this distance as a result of bending the sponge.
11. What happened to the overall length of the horizontal line? Answer: nothing. The length of the line is not changed.

The length of the horizontal line, and distance between the vertical lines, remain unchanged. This is because the beam is neither in compression nor tension along this line. The horizontal line is called the neutral axis of the beam. The ruler also has a neutral axis, but its thickness is too small for the neutral axis to be observed.

ACTIVITY #2

1. Have the students hold the sponge at one end and then push down on the other end with their fingers. The vertical and horizontal lines should be facing the students as before.
2. A beam supported at only one end is known as a cantilever beam. Cantilever beams are used to create balconies in buildings and other types of overhanging structures.
3. What happens to the vertical lines when the sponge is supported and loaded like a cantilever? Answer: the vertical lines spread apart along the top edge and become closer together along the bottom edge.
4. Have the students identify the beams used in the construction of their school building or other buildings which are familiar to them.

INSTRUCTOR'S ASSESSMENT

1. How would you assess the outcome of this lesson?
2. After presenting this lesson, what would you change in the next presentation of this lesson?
3. What feedback did you receive from the students?
4. Were the students able to grasp the concepts of this lesson?

The Next Step

The forty-five lesson plans mentioned above are undergoing a final editorial review. Faculty in the Department of Civil Engineering at the University of Cincinnati are contributing to the editorial review. As a part of this review process, selected lesson plans will undergo "field trials" in both Arkansas and Ohio. Planning has begun to test all of the 3rd to 5th and 6th to 8th grade lessons in an area grade school where there are 5 classes for each grade level. Upon the conclusion of all reviews, the lesson plans will be recorded to compact disk and disseminated to anyone wishing to have a copy.

Closing Remarks

In an effort to educate more children in grades K through 8, a set of forty-five lesson plans focusing on the profession of Civil Engineering were created. In addition to the lesson plans, bibliographies, vocabulary lists, still images, and digitized videotapes are included on a single compact disk. All the aforementioned materials are accessed through a web-based interface. The lesson plans are in their final stages of internal review and then will be available free of charge to those who desire a copy.

Requests for a disk can be made to:

Lesson Plan CD Request
Mack-Blackwell Transportation Study Center
4190 Bell Engineering Center
Department of Civil Engineering
University of Arkansas
Fayetteville, Arkansas 72701

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Bibliography of Internet Sites

The following is a list of internet sites which provide guidance for the creation of a lesson plan, provide access to free lesson plans, or both. Information gathered from these sites was considered while developing the lesson plans described herein.

1. www.lessonplanspage.com
2. www.lessonplancentral.com
3. www.americateachers.com
4. www.educationplanet.com
5. www.engineering.usu.edu
6. www.proteacher.com

Biographical Information

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