# AC 2011-1294: CURRICULAR EXCHANGE BETWEEN A STEM UNIVERSITY AND A RURAL ELEMENTARY SCHOOL: THE ESTABLISHMENT OF AN INTERACTIVE VIDEO LINK

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# Curricular Exchange between a STEM University and a Rural Elementary School: The Establishment of an Interactive Video Link

As part of an educational partnership between a university and an elementary school, an interactive video link has been established between the participating schools. The interactive video link supports the exchange and delivery of curricular materials across approximately 250 miles and minimizes the need for individual travel. The participating universities primary focus is on science, technology, engineering and mathematics; the elementary school serves students in grades kindergarten through fifth grade who live in a rural region. Through funding of ExxonMobil Foundation, this university/elementary partnership has been established to improve young students understanding of science and engineering by enriching the curriculum with the use of hands-on activities.

During the summer of 2010, seven elementary school teachers, representing grades K-5 and the schools science specialist, attended a summer workshop on the universities campus. This workshop was rich with hands-on science experiments that could be used in the elementary classroom. A graduate student from the university also attended. Immediately following the workshop and at the start of the school year, the graduate student traveled to the participating elementary school, was introduced to the students, and presented an initial lesson plan. The purpose of this visit was to meet the students before interacting with them via the interactive porthole. This made the graduate student real to the participating students. In this initial presentation, food coloring, water and strips of paper towels were used to stimulate and study the capillary action of a candles flame. The students also learned how to form and tests hypotheses.

The next phase of this project is to continue communication between the university and elementary school via the interactive video link. It is the participating graduate students responsibility to communicate with the school and provide it with instructional support for up to 15 hours every week. Future lessons are planned that include the examination of states of matter and, in the upper grades, the extension of these states to clathrate hydrate cells. Clatherate hydrate cells are flammable ice like structures that can be set on fire, demonstrating the unique relationship between natural gas and water under certain set pressures. Due to the involvement of fire in this experiment, students will observe the experiment via the interactive video link rather than participate. Other lessons are planned in which students will complete the activity at their site simultaneously with the graduate students demonstration. These experiments will be collected and built into curricular units throughout the academic year. A primary form of assessment will be comparisons on baseline measures of the students performance on the states mandated science test prior to and following this intervention.

## I. Introduction

As a result of the project, *Educational Partnership Between Colorado School of Mines and Meeker Elementary School*, the Colorado School of Mines (CSM) and Meeker School District Re-1 have established a collaborative relationship with the purpose of improving K-5 instruction in mathematics and science. The goal of this collaboration is to transfer research and curriculum that is being developed as part of the Bechtel K-5 Educational Excellence Initiative for use at Meeker Elementary School (MES). A major hindrance to this effort has been the 250 mile distance from MES to CSM, a portion of which is on rural roads and over the Rocky Mountains. These factors prevent regular visits and in-person meetings between MES and CSM faculty, which is possible with CSM's local partner elementary schools. As part of this project, MES teachers attended a summer workshop in 2010 at CSM and will attend a second workshop in 2011. Equipment has also been purchased to support electronic site visits to MES by our graduate student, Van Blackwood (see: http://inside.mines.edu/ vblackwo/), and faculty, and to provide the electronic instructional support to MES.

Through a broader initiative, CSM is working with K-5 teachers to increase their competence and confidence in mathematical and scientific content, in the use of manipulatives and technology, and in the integration of reading instruction in mathematics and science content delivery (see: http://mcs.mines.edu/Research/bechtel/new/). This is being accomplished by offering cohorts of K-5 teachers two, two-week summer workshops on CSM campus, over successive summers, in mathematics and science with an energy and renewable energy emphasis. Each cohort consists of a teaching team representing all grade levels, K-5, within a given elementary school. These workshops are taught by CSM researchers and researchers from the National Renewable Energy Laboratory (NREL).

Implementation of workshop activities in the elementary classroom during the academic year is not left to chance; rather, graduate students directly assist the participating teachers for up to fifteen hours per week, throughout the academic year, in implementing the discovery-based learning activities in the K-5 classrooms. These same graduate students are also responsible for 1) arranging visits by prominent CSM and NREL researchers to the K-5 classroom, 2) researching additional mathematical and scientific classroom topics, and 3) arranging elementary school campus tours of CSM. Since mathematics and science comprise, on average, forty-five minutes of an elementary school day, we have found that one graduate student is sufficient to support up to seven elementary school teachers (this includes all grade levels, K-5, and the English as a Second Language Instructor).

In order to offer this program at a distance to MES, several adaptations have been made. First, MES teachers traveled to CSM for a two week summer workshop in 2010. This was funded by the ExxonMobil Foundation and supported the establishment of a personal relationship between CSM faculty and graduate students and the MES teachers. Additionally, it provided the teachers with hands-on experiences in mathematics and science and in applying these concepts to energy and renewable energy applications. The first workshop occurred in the summer of 2010 (July 12 to July 23, 2010); the second workshop will occur in the summer of 2011.

Second, CSM graduate students cannot regularly attend and provide support to the MES classroom due to distance. Instead, as part of this project, the ExxonMobil Foundation funded the purchase of an interactive video connection which has been established with MES. Van Blackwood, a graduate student in Engineering at CSM and the first author on this paper, has been providing support to MES through the fall semester via interactive video. Through this porthole, Mr. Blackwood and faculty from CSM visit MES classrooms electronically. The equipment provided to both Colorado School of Mines and Meeker Elementary School include a plasma TV, and echo canceling microphone, and remote conferencing software and hardware by Vidyo. The equipment is used by the teaching fellow to articulate and demonstrate engineering and scientific concepts to students attending K-5 in Meeker, Colorado.

## II. Description of MES

The focus of this paper is on of the first lesson that was taught at MES by Mr. Blackwood. MES is rurally located and is a ranching community located in north central Colorado, approximately 250 miles away from CSM. The lesson described here was presented to grades K-4 science classes and was used to introduce the participating students to Mr. Blackwood. The average class size in MES is about 15 students per class.

## III. Lesson Plan

### How does the wax get to the flame? - States of Matter, Jumping Flames, Capillarity, and Siphons

***Materials:***

Food Coloring

Water

2 clear bowls

Paper Towel Strips

Paraffin Candle

Lighter

***Purpose:***

The purpose of this lesson is for students to explore the answer to the following scientific question: **How does the wax or fuel of a candle feed the flame?** This lesson teaches students to form and test hypotheses, through an instructor-guided question and answer session.

***Colorado State Standards:***

The lesson described below addresses Colorado State Standard 1 for Physical Science. The lesson was presented to grades K-4 and therefore, the appropriate standard for each grade is identified here:

***Kindergarten:*** Objects can move in a variety of ways that can be described by speed and direction

***Grade 1:*** Solids and liquids have unique properties that distinguish them

***Grade 2:*** Changes in speed or direction of motion are caused by forces such as pushes and pulls

***Grade 3:*** Matter exists in different states such as solids, liquids, and gases and can change from one state to another by heating and cooling

***Grade 4:*** Energy comes in many forms such as light, heat, sound, magnetic, chemical, and electrical

***Overview:***

A flame attached to a candle is something that is not typically recognized as rich, scientific phenomena which can be investigated by elementary school students. However, through closer examination, we find that several fundamental scientific concepts can be learned by observing the nature of a candle being consumed by flame.

This lesson was derived from Michael Faraday's lecture series "The Chemical History of a Candle", which was first presented in 1861[1]. Adaptions have been made to this lecture to appeal to and inform a young audience.

Since the lesson is based on observation (the students watch the candle burn), and the depth of the subject matter is controlled by the students curiosity. This makes it easy to adapt the lesson to multiple age groups and learning levels. The lesson is guided by questions in response to the students observations. The purpose of this laboratory and the big challenge to students is, "**How does the solid fuel or wax get to the flame?**"

***Teacher Background:***

***States of Matter:*** Solid, liquid, gas, and plasma.

***Capillarity:*** The ability of a narrow tube to draw a liquid upwards against the force of gravity.

***Siphon:*** A pipe or tube fashioned or deployed in an inverted U shape and filled until atmospheric pressure is sufficient to force a liquid from a reservoir in one end of the tube over a barrier higher than the reservoir and out the other end.

***Discovery:***

1. Ask students:

**What do they know about flames and candles?** and **What is needed to make a fire burn?**

These questions are intended to stimulate the students' thinking to identify the fuel and oxidizer. In this case the fuel is wax and the oxidizer is air. If the flame does not have both of these, the flame will extinguish. Since the flame is surrounded by air, there is an abundance of the oxidizer or air supply. The important component is fuel and how it migrates up the wick to the flame. A match is also needed to ignite the flame. Once the concept of fuel and oxidizer is established, light the candle. Warn the students that they should not try this experiment at home unless an adult is providing assistance and is lighting and overseeing the flame.

2. Ask students;

**How does the wax (fuel) get to the flame?**

Let them know that this question is the primary focus of the experiment. Have the students write the following question down.

After defining the problem statement the students are asked to focus the part of the candle that is holding the flame, liquid wax, and the solid part of the candle just below the liquid wax (see Figure 1).

3. Hold the candle and walk around the room to each student and ask:

Figure 1: Focal point for problem statement

**What do you see?**

The observations covered a range of ideas: how the wax melts, how the candle reshapes, the color of the wick, and questions concerning the gap between the flame and the wick. Students should be encouraged to record their observations in diagrams or through text, depending on grade level. These observations can be connected with questions relating to states of matter, capillarity, and siphons. Colors of the flame were intentionally left out of the lesson plan because of the complex nature of describing radical formation and molecular vibrations that emit energy at wavelengths that correspond to the visible part of the electromagnetic spectrum. However, such a discussion could occur in middle school and high school classrooms, illustrating the broad spectrum of grades in which the ideas presented here may be pursued.

**Questions with respect to states of matter:**

Have the students discuss:

**Why is the candle wax turning to liquid?**

The students should connect the heat or energy released from the flame to the change of state in the wax, liquid to solid.

5. Ask students:

**What is the shape of the solid part of the candle that is holding the wax? Why does the solid part take that shape?**

Question 5 is advanced. The shape of the solid part of the candle is a mirror image of the bottom portion or the part of the flame closest to the wax. The bottom portion of the flame is roughly a hemisphere. The heat from the flame radiates from the flame to the wax. The wax is melted in the shape of a hemisphere or bowl.

6. Have the students discuss:

**Is there vapor or gas phase of the candle wax?**

Most will say no and for the most part this is correct. The teacher should blow the candle out and let the students observe the wax vapor. Mention a test to see if this is wax vapor is to see if it is flammable. Light the vapor and the flame should move from the lighter, down the trail of wax vapor to the candle wick. The flame will be held at the wick where a constant stream of fuel is contained.

7. Have the students answer the question below:

**Why isn't the wick burning?**

The liquid wax that is traveling through the wick absorbs heat from the flame until it turns into a vapor. Once in the vapor phase, the vapor moves toward the flame. As the vapor moves toward the flame, oxygen from air is moving through the flame to the wax vapor. When the temperature is high enough the wax vapor and air contribute to the life of the flame. This is why the flame stands a certain distance away from the wick.

**Questions with respect to capillarity and siphons:**

8. Recast question 2:

**How does the flame contribute to the liquid wax moving up the wick?**

This is where the lesson shifts from the lit candle to a demonstration using two bowls, colored water, water, paper towel strips, and a sponge. Fill one of the bowls with water and add food coloring. The bowl filled with colored water symbolizes the wax reservoir in the candle. Place the bowl on a book. Place one end of a paper towel strip into the colored water and watch the colored liquid move up the strip. Explain that the wax moves similarly up the wick against gravity. The movement is capillary action and it requires very small pores in order for it to work. The liquid water or wax is attracted to itself and to the paper towel or wick. Since the liquid is attracted to the wick, it moves into the wick and pulls more liquid with it. The colored water will only travel up the paper towel until it cannot oppose gravity. In order to keep the liquid moving through the paper towel, a siphon is made. The siphon represents the flame. The siphon is made by placing the dry end of the paper towel strip into the second empty bowl. The second bowl should be placed lower than the bowl with colored water. Eventually some of the water from the full bowl will drain into the empty bowl. First, capillarity was used to move the water into the paper towel. Second, to consume the water, gravity was used to move the colored water from the full bowl to the empty bowl like a siphon. A candle flame is similar because the wax moves up the wick and is consumed by the flame creating a constant stream of wax that feeds the flame.

## IV. Implementation

The lesson was taught by Mr. Blackwood and was his first introduction to the MES classrooms. For this lesson, Mr. Blackwood had traveled to MES, but future lessons where implemented via the interactive video with the teacher mimicking Mr. Blackwood's demonstrations onsite. A series of general questions were asked to assess students' knowledge of fire and flames. The questions were used to assess the students' scientific level prior to implementation and helped the students to relax and engage in the activity. By beginning with simple questions, "What do you know about fire?," all students, regardless of level, were able to engage in the activity. As is illustrated through the lesson plan, the questioning process became more complex and in depth as the lesson progressed.

The Candle is lit and the graduate student walks to each student or group of students and asks them to make observations about what they see. This component allows the graduate student to work closer with the students. This was done to engage students that are shy or to students that will not answer questions in front of their peers. This approach allows the graduate student to guide the lesson by adjusting or recasting information to the learning level of the student. If a student made observations beneficial to the entire classroom, their statement was shared with the class. After the candle has been observed by the students, the siphon demonstration is completed.

The siphon demonstration is used as an analogy for the flame. The demonstration was performed in the front of the class. This last section served to summarize and solidify concepts presented during the candle demonstration. The bowl acts as the wax holder that is seen in the candle. The colored water is the wax. The paper towel strips act as the wick.

***Student Response:***

The third and fourth grade students, in general, were attentive and excited about the demonstration and they asked many questions. The demonstration stimulated questions relating to buoyancy with respect to the flame density relative to air. Students drew a broad range of pictures illustrating candles to convection cells. Students also recorded their observations. There were no disruptions due to behavioral issues. One student noticed that the colors were separating as they moved up the paper towel. We discussed separation techniques in chemistry such as chromatography.

Kindergarten through second grade students were far less interested in the experiments. Although they were entertained by the candle flames, they did not understand the vocabulary. If this lesson plan is used with this age group, additional adjustments and simplifications should be made by someone with age appropriate expertise.

## V. Conclusion

This lesson could be implemented from kindergarten through college, with appropriate adaptions. The experiment can also be implemented remotely by having the onsite teacher mimic the demonstrations and help the students observe the candles; the remote presenter would respond to questions and guide the experimental process. The siphon component of the lab can be hands on at any grade level. The students can be divided into groups and observe capillarity and build a siphon. Guiding questions can be provided through instruction or completion of a worksheet.

[1] Faraday, Michael (1861). W. Crookes. ed. **A Course of Six Lectures on the Chemical History of a Candle.** Griffin, Bohn & Co.