P1.28 METEOROLOGY EDUCATION THROUGH NATURE CENTERS

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1. INTRODUCTION

For over a decade there has been a repeated national call for greater instructional emphasis on integrating mathematics and science posed in "real-life" situations. National educational associations such as the National Council of Teachers of Mathematics (NCTM) and the National Science Teachers Association (NSTA) support the notion that access to effective mathematics and science education be made available to all children. In parallel there has been a push for scientists and engineers to work to augment math and science education to provide a pipeline into these fields. These dual goals have the potential to provide a marriage of scientists and engineers with professional educators to produce a stronger mathematics, science, and technology education. Meteorologists have been highly involved in this effort.

Traditionally, mathematics and science are subjects taught separately in schools and relegated to specific points within the daily schedule (Barba, R., 1995). Numerous studies show that the teaching typically relies on expository teaching methods that all too often have the children experience the learning from a distance. As casual bystanders, they become disenchanted with subjects and knowledge that should cause them to brim with excitement and anticipation.

Informal means of education are sometimes more effective since the students can become immersed in applications of the science. Nature Centers are an excellent alternative means of educating the public about natural science. They reach a wide audience with an age range varying from preschoolers through adults. Many of these centers do a wonderful job of educating in such areas as biology, geology, and environmental science; however, it is seldom that one sees a nature center exhibit or program that emphasizes physical science or mathematics. In this project we sought to provide this missing element by developing displays and programs that use meteorology to exemplify physical science and mathematics in the natural world. When people learn about physical science and mathematics in an informal setting, they see the relevance and applicability of what they learn.

This project seeks to provide a paradigm of cooperation between informal education centers, formal education, higher education, and industry to enhance opportunities for learning science and mathematics. Interactive displays and programs have been developed and piloted in a collaborative project between a nature center, a local manufacturer of meteorological equipment, and several university departments. In addition, teachers were surveyed and consulted in developing the program. The displays and programs use the natural themes observable in the surrounding environment. The centerpiece of the education programs is a weather station sited near the Nature Center. This station presents a display within the Nature Center and includes interpretative plots of the data. Data are integrated with other data from nearby stations. Displays are included to explain the weather and climate of the region as well as instrumentation. In addition, children's programs have been developed for visiting school groups and for teachers who wish to develop classroom meteorology units. Specifically, physical science and mathematics State Core Curriculum objectives are integrated into the presentation and study of meteorology through hands-on displays and experiments. The programs include using the data from the weather station, outside environmental observation, and using simple instruments to measure meteorological variables. Students use this integrated picture to predict the next day's weather. Teachers may then follow-up in the classroom to assess the children's predictions. In this way, school children learn about meteorology in the natural environment plus use mathematical skills to put their newfound knowledge to work.

2. STOKES NATURE CENTER

Stokes Nature Center is an example of how many informal education opportunities work. They include both formal activities for school classes to use as field trips as well as including displays that anyone can view upon visiting. It is situated at the mouth of Logan Canyon (Fig 1) and is serving as the pilot site for this project. The center is a non-profit nature education facility (see http://www.logannature.org/). It provides field-

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based science education programs for all ages. The programs include:

- Field programs designed for school field trips, correlated to the Utah State Core Curriculum, including pre- and post-visit lesson plans.
- Saturday family programs: one week per month of nature programs for all ages and another week emphasizes activities for children ages 6-8.
- Winter safety and winter survival programs, designed as special programs for one day or one evening plus one full day in the snowy outdoors on a snowshoe trip. This program is popular with Boy and Girl Scout troops.
- Summer Dipper Day Camp, which is a chance for elementary students to spend a week of summer days exploring Cache County's diverse habitats and wildlife.
- Displays within the Nature Center building, accessible to drop-in visitors during the hours of operation.

Topics for the programs include exploring river water quality by collecting and identifying invertebrates, hands-on ecology, plant and animal seasonal preparations, soil science, tree ecology, geology, and the inner workings and transport of seeds.

Various local schools use Stokes Nature Center to facilitate their teaching of science. The Nature Center receives excellent feedback from excited children, teachers, and parents on their presentation techniques and their methods of integrating the surroundings into their lessons. Programs such as the one presented here are examples of opportunities for the public to learn about science in an informal setting. It reaches people from all walks of life. The informal nature of the Center allows children to learn without the usual pressures of schoolwork, thus being accessible to students who may not be traditional learners. Similar opportunities abound at other informal education venues.

FIGURE 1. Stokes Nature Center in Logan Canyon

While there is much that is positive about the efforts of the Stokes Nature Center and other centers like it, we believe a weakness is that there is a general lack of emphasis devoted to physical science and mathematics. Of course, physical science and mathematics are also intrinsic parts of the natural world. One example of a physical science that is quite amenable to the type of learning that goes on in a nature center is meteorology. The science of meteorology is also an excellent example of a science that deals with data in a very mathematical way, thus being a wonderful opportunity to present mathematics as part of nature.

3. DATA COLLECTION

To meet the goals of providing enhanced mathematical and physical science curriculum, we concentrate on working with real-time weather data. The project goes beyond the typical cloud and sky observation to teach students to evaluate data to determine the "why's" of how the weather works. Thus, the first step of the project was to obtain equipment to measure meteorological variables. A weather station has been sited at the nature center (see Figure 2). Campbell Scientific, based in Logan, is one of the primary sources of weather stations in the United States. They have donated equipment for a fully functional weather station to Stokes Nature Center and provided manpower to set the equipment up within usual specifications. Variables measured include air temperature, relative humidity, wind speed and direction, barometric pressure, precipitation, and solar radiation. Additionally, Campbell Scientific has four other weather stations sited in Cache Valley with data accessible online. Siting the weather station required the co-ordination of the university investigators, Campbell Scientific personnel, nature center staff, and the US Forest Service who owns the land on which it is sited. A proposal was written

FIGURE 2. Weather station and rain gage at Stokes

to justify a categorical exclusion and a public comment period was held. The comments were all positive and the Forest Service granted the exclusion.

Telephone lines provide communication between the weather instruments mounted on the roof (Figure 2) and a data logger that includes software programs to retrieve the data and graphically display it on a computer sited inside the Nature Center. The computer displays are programmed to specifically show the variables of interest at the current time as well as to allow viewing historical data.

A second type of data acquisition is via hand-held monitors that groups visiting the nature center can take into the field. These devices include thermometers, hygrometers, and manometers. These are hardy in nature so that they can be used by many groups over a long period of time.

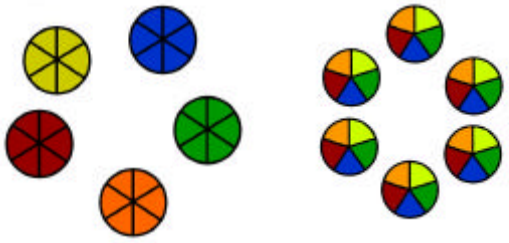
The weather data is an important part of providing Nature Center patrons with opportunities to assess the physical and mathematical basis of meteorology. The project provides educational opportunities centered around the way people typically visit the nature center.

4. DEVELOPING AND PILOTING THE CURRICULUM

A curriculum has been developed to facilitate learning by school groups that visit the Center on field trips or by summer camps. This curriculum was specifically targeted to meet the Utah Core Curriculum requirements for Fourth Grade under the topics of Atmosphere and Weather and Mathematics. It is designed to have three major modules: 1) an in-class learning experience prior to the visit to Stokes, 2) an on-site portion that involves hands-on learning, and 3) a post-site portion that emphasizes follow-up and taking the learning experience a step further. The emphasis of the pre-site learning experience is to have each child participate in a group that becomes expert in an area of meteorology. The focus areas are: 1) temperature and solar radiation, 2) pressure and elevation, 3) wind speed and direction, 4) humidity and precipitation, and 5) cloud cover and type. When the students arrive for the site visit, each group briefly informs the rest of the class about their own area of expertise. Then the groups are mixed so that there is at least one expert in each focus area in each on-site group. This group mixing is shown schematically in Figure 3.

For the on-site module, meteorology principles are learned through observation and data collection. The weather station data are used to observe the current weather variables (temperature, humidity, wind speed and direction, solar radiation, and precipitation). In addition, students are able to observe historic time series of the data and use them to interpret the current and past weather. Longer time series indicate the climate of Logan Canyon. Even the unique location at the mouth of the Canyon is useful: students can observe a shift in wind direction according to the time of day. A computer is dedicated to the program to allow data analysis and connection to the internet so that other local weather stations can be observed. Campbell Scientific also has weather stations located elsewhere in Cache Valley. Students can compare these data under various situations. They can observe geographic and orographic effects through this comparison. The students can also observe time series on various scales to note trends in the data or to consider the climatology of the region. The students are then taken into the field to do their own sampling of meteorological data. Thermohygrometers are provided to groups of students so they can observe local variations of temperature and humidity around the Center locale. They observe clouds and weather patterns and record their observations on worksheets. They are provided with cloud field guides to identify current conditions. They are asked to interpret these conditions and use them, together with the data, to make a short term forecast that would be relevant to a camper or hiker in the Canyon. Children then develop a presentation of their findings and forecasts to present to the group. During wrap-up, staff discuss the most recent National Weather Service forecasts and how they relate to observed conditions.

FIGURE 3. Pres-site groups (left) become expert in their areas and are remixed for on-site activities (right)



Teachers are provided follow-up materials so that they can further discuss the results of the local forecasting on subsequent days. In addition, teachers are given the tools and encouraged to practice the observing and forecasting techniques with their classes over a longer period of time. In this manner, students learn how to integrate and interpret their observations, fitting them into a model that can then be used to understand the world around them. The post-site curriculum also encourages further exploration into areas that interest groups of students. One group may choose to study weather lore through the ages. Another group might investigate the use of satellites for weather observation. A third group may choose to learn how weather data is incorporated into

models to predict weather. A wealth of opportunities exist for this deeper exploration and we merely suggest a few possibilities.

The curriculum for the school program was piloted in March 2002, with the help of a Utah State University class in Environmental Education that served as facilitators during the on-site portion of the learning experience. Nine fourth grade classes participated in the on-site presentation at Stokes, each arriving at a separate scheduled time. Since it was the first presentation, most of the teachers had not been able to use the pre-site materials and the on-site curriculum had to be modified to accommodate such classes. However, the program was quite well received, with an exit survey of the teachers that praised the group work and organization. Six of the responding teachers rated the program excellent and two rated it very good. Five teachers specifically indicated that they would use the pre-site materials in future years. The best evaluation was seeing the excitement of the students (Figure 4)

FIGURE 4. Children measure meteorological variables in pilot program at Stokes Nature Center.

5. DISPLAY FOR NATURE CENTER

A display centered around meteorology has also been prepared for Stokes Nature Center. The centerpoint of the display is the computer that records and displays the data from the weather station. The computer display is interactive, giving the visitor various options for viewing data. Displays of current data are presented in terms of histograms, dials, and data thermometers. The user may switch the view to plot time series of historical data over a variety of time frames. Plots are of various types, ranging from a simple time series that shows hourly changes to very long-term displays, such as histogram plots of a variable, such as temperature, which help interpret the climate of the region. Also, the visitor is invited to compare the local data with the other stations throughout Cache Valley.

In addition, the changes in weather monitoring through the years is displayed to the left in a tri-panel display. Past instruments, such as a working Galileo manometer is displayed in a plexiglass case. Question boards allow the visitor to guess answers to questions about the workings of such instruments. They are encouraged to further understand the physical principles through inquiry. The middle display is sited over the computer and emphasizes modern instrumentation techniques. On the right panel, a photo of the weather station is included and as well as an explanation of how the various variables are measured. Overtop it all is a cloud mural that paints the differing types of clouds at the appropriate level in the atmosphere (see Figure 5). The displays can be viewed either by school groups or informal visitors.

FIGURE 5. Cloud mural that is a focus of the meteorology display at Stokes Nature Center.

6. TEACHER TRAINING

An important part of providing a curriculum for school children is giving the teachers the tools to use it. In this vein, the curriculum has been carefully developed to include inserts of information for the teacher and to give the teacher a list of suggested references that will help him or her to develop further expertise in given areas. Techniques are suggested for not only capitalizing on the hands-on learning opportunities available for their students through nature centers, but also how they themselves can create learning situations effectively integrating science and mathematics. These activities capitalize on the natural environments found around their schools and throughout their communities.

As part of this project a special section of a graduate course for in-service teachers dwelt on the methods used in this curriculum. This curriculum was set up as an example of a pedagogical focus to reiterate the fact that students can gain significant science and mathematical knowledge when the learning situations are predicated on solving realistic problems. The group learning focus was presented and emphasis was placed on students being successful when posed

with problems found in their natural environment. As students acquire scientific and mathematical knowledge through their study of meteorology, they will learn to apply what they know to analyze and predict weather conditions and relationships. It is expected that the students will not only gain in their understanding of weather phenomena but will also learn how the mathematics and scientific concepts being learned are relevant and applicable to their daily lives. By using these techniques on this particular project, teachers are asked to evaluate their use in other teaching situations as well.

7. CONCLUSIONS

By observing meteorological data and conditions, visitors to Stokes Nature Center can integrate the physics and mathematics of the natural surroundings and use the tools available to interpret and predict future conditions. In addition, learning modules have been developed for visiting school groups and which may be used by teachers who wish to develop classroom meteorology units. These programs have been piloted and assessed as being useful for the teachers involved. The curriculum is now available on the web. In addition, a weather station and a display have been sited at Stokes Nature Center that allows the visiting public to view real time meteorology data and describes the tools to interpret it.

This project was designed as a model that can be expanded to other nature centers throughout the state and region. Our hope is that by collaborating with informal education environments, we help develop a new paradigm for educating the public in science and mathematics. Achieving these goals will help increase the public's (and particularly school children's) abilities in science-related areas.

Real mathematics and scientific inquiry is important to help students develop productive views of the nature of mathematics and science. When students understand mathematics and science as dynamic processes, rather than static sets of facts to be learned, they are more successful at inquiry and continued learning.

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