

23. Ground and Surface Waters

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As an integrative discipline that uses all other sciences, the earth sciences are logical vehicles for inducting students into the scientific world. Students are naturally interested in the world that they see and experience. This interest gets their attention and willing participation by pursuing answers to questions about the Earth and its environment. Mathematics and the basic sciences can be naturally and unobtrusively introduced in the process, often without the students even being aware that they are studying anything but the Earth. Because middle school science tends to be integrative in nature, the earth sciences are the natural bridge that connects the curriculum. However, this is also true at the high school level, especially if the school uses earth science as an introductory or science-literacy course.

Participation

Because Rockford does not have an earth science curriculum at the high school level, we worked primarily with middle school personnel.

We participated in several aspects of the program, but here we focus on only two of those: the Educational Pathways to Careers workshops and the content-area workshops. In the former, we hosted rotating groups of middle and high school teachers in their first year of the development program.

The content, or discipline-update, workshops involved only middle school teachers. During the first year of our participation, the workshop was only open to public school teachers who were participating for the first time. In the second year, the content workshop was restricted to the same cohort of teachers, but we did not require them to have attended our first-year workshop. Therefore, our second-year participants included teachers with whom we had worked the previous year and others who were with us for the first time.

Objectives

An objective of the pathways workshops was to provide the teachers with accurate information for advising students who might have an interest in the geosciences. A second was to encourage them to speak positively about earth science to their students, to include geoscience topics in their classroom, and to induce them to consider participating in a later workshop to acquire greater knowledge of the subject.

The first content workshop was a three-day experience distributed across all areas of science, with fluids as the theme. Physics and geology worked together for 1.5 of those days, with the first day being led by physics and devoted to exploring flow in its various aspects. Only one morning was devoted exclusively to earth science. The objective for this half-day was limited to developing a concept introduced in the pathways workshop. The second content workshop introduced a variety of activities related to the goals and standards developed by the

Rockford school district for middle grades. We planned the workshop based on discussions with the prospective teacher participants.

Rationale and Motivation

Most middle grade teachers hold elementary certificates and usually have only a modest number of credit hours in any one content area. Science hours are often primarily in life sciences, with some exposure to chemistry. However, middle school curriculum generally attempts to follow an interdisciplinary, although not usually integrated, approach to science. The teacher is, therefore, responsible for teaching all areas of science and often for interrelating that science to concurrent curriculum in social studies, English, or mathematics.

Earth science, by its nature, is an integrative science that uses the other sciences, and in this respect is the ideal vehicle for teaching science in the middle grades. Students easily relate to many aspects of earth science because they encounter them daily. For example, they experience rain, observe water running off the surface, and know that water soaks into the ground. Second, pursuing topics in earth science requires the application of principles from chemistry, physics, and the life sciences. Hence, in the process of learning about something that has relevance to them, they also learn the other sciences in context.

We wanted to show teachers the advantage of using the earth sciences in this context and to provide them with activities they could take into their classrooms. Most teachers have limited resources for their classrooms. Consequently, it is always our objective to present activities that are scientifically sound and can be done at little cost. Our chosen hook was the action of water on and below the surface of the land.

Educational Pathways to Careers

The teachers received these workshops well. The plenary sessions are discussed elsewhere in this volume, so we will address only the earth science sessions, which were conducted in three successive years. Each session was divided into a discussion of career opportunities and program requirements and an introduction to selected activities that the teachers might take back to the classroom.

The teachers enjoyed discussing career opportunities and learning about the program requirements that their students would need to meet if they wished to major in the earth sciences. Because Northern Illinois University has a leading-edge approach to the preparation of secondary teachers, participants were especially interested in talking about the department's teacher education program. In most sessions, this part of the program consumed about two-thirds of the allotted time.

For the second part of the session, we chose running water as the theme. We presented activities that spanned grades 6-12 and focused on streams and their properties. These ranged from a very simple experiment requiring only a short piece of rain gutter and a plastic milk bottle to a more complex, commercially built stream table. Participants explored the relationships between water discharge, velocity, and slope and looked at erosion caused by raindrop impact and running water. Most of these activities were taken from published sources. In general, the participants were most interested in the stream table demonstration and the interesting activities to augment the career discussion.

Content workshop 1

This workshop was open to middle school teachers who were first-year participants in the Rockford program. This was a three-day session with fluids as the theme. Physics, with support from us, led the first day and explored many properties of fluids. We subsequently led a half-day session that was divided into two parts. One part expanded the first day's study of fluids with an introduction to the influence of water and its properties on geologic processes. Magma, another fluid, plays a significant role in geology that is highly dependent on viscosity, so we next investigated that property. Experiments involved flows of water and syrup, including laminar and turbulent flow, done in a section of rain gutter.

Content workshop 2

Offered the following year, this one-day workshop involved only the earth sciences. It was open to the same group of middle school teachers as were eligible for the previous workshop. Although most of the participants had taken part in one of our pathways sessions, many had not been in the first workshop. Most were teaching curricula that incorporated the topics of water and soils to varying extents.

For this session, we generalized the theme slightly and used the fundamental states of matter as the connecting thread, although the emphasis continued to be on the fluid state. Using the school district's website, we aligned the workshop material with its goals and standards for grades 6-8. This articulation was then noted at appropriate points during the workshop.

The Rockford school district has defined goals that are the same for grades 6, 7, and 8. Activities in the workshop primarily addressed goals 11 (Inquiry: Understand the processes of scientific inquiry and technological design to investigate questions, conduct experiments and solve problems) and 12 (Concepts: Understand the fundamental concepts, principles, and interconnections of the life, physical and earth/space sciences). The district defines several standards within each goal, each with specific indicators. For example, within goal 12, two standards that we especially addressed were standards C (Know and apply concepts that describe properties of matter and energy and the interactions between them) and E (Know and apply concepts that describe the features and processes of the Earth and its resources). "Describe the process of the water cycle" and "Formulate a hypothesis that can be tested by collecting data" are examples of indicators within these standards.

When designing the workshop, our goals were to increase the teachers' knowledge in the content area, enhance their skills in using that knowledge, convey the concept that both process and product are important in earth science, provide motivation to incorporate the material into the classroom by relating it to district standards, suggest strategies for making content accessible to students, and demonstrate that activity-based instruction can often be accomplished with low-cost resources.

Morning session

Most of the morning session was devoted to the fluid state, specifically to running water in the form of streams and ground water. We again started with properties, with activities

focusing on surface tension, cohesion, adhesion, and capillary action. The impact of these on geologic processes was always emphasized. A brief discussion of viscosity was also included as a link back to its introduction in Workshop 1 and forward to the afternoon session.

With the basic properties established, we turned to a discussion of ground water. After *defining* the water table, activities focused on porosity, permeability, and liquefaction. Again, these were related to district standards and were placed in a geologic context, including discussions of such geologic hazards as slope failure and the effects of ground water mining.

We concluded the fluid/water portion with concepts and activities associated with surface runoff, both sheet flow and stream flow. Activities related to stream load (sediment) logically led to the topic of erosion and transportation. At this point, the participants used one of the stream tables that had been constructed in Workshop 1 to investigate the interaction between streams and sediments under varying conditions.

Afternoon session

The afternoon session shifted to matter in the solid state, with a focus on deformation of solid materials, specifically elastic, plastic, and rupture. Plastic flow in the mantle served as the transitional link from the morning's discussions of fluid flow. One of the geologic consequences of deforming rock materials (tectonics) is the occurrence of earthquakes.

We pursued this topic with a discussion of where, when, and how earthquakes occur and of their consequences in terms of seismic vibrations and their impact on society. Discussion and activities addressed elastic strain accumulation and release, characteristics of wave propagation, epicenter location, geologic associations, and data presentation and analysis (graphing opportunities that support standards objectives, such as computing velocity from a time vs. distance plot).

Our final segment addressed the possibility of predicting and mitigating earthquakes. Participants divided into teams charged with designing and building structures to withstand an earthquake. Materials for the structures consisted of blocks of florist foam to use as a base, sheets of foam for the buildings, and a large supply of toothpicks with which to affix the pieces. The integrity of the structures was then tested by imposing a static load. While not strictly analogous to earthquake-imposed stress, the exercise conveyed the concept.

Closing Thoughts

The teachers were responsive and enthusiastic, especially in the content workshops, and they had positive assessments. From our perspective, the experience was quite useful. We perceive the following benefits to ourselves:

- A better understanding of our colleagues working at a different stage in the educational endeavor and of the problems that they face.
- An enhanced recognition of the need to relate to district standards, establish coherent program goals, and set objectives in our own teaching.
- A greater awareness of the pedagogical need to address different learning styles in our classes and to actively engage students in their own education.

Recommendations

Programs like this are worthwhile for both the public school and university faculty. We encourage university faculty to become involved in providing professional development opportunities. However, preparing and delivering these events takes considerable time and effort. Simply delivering a content lecture, too often the mode of instruction at the university level, will not be effective.

Public school teachers are practically oriented and will respond positively if the content is presented in a mode that is appropriate to their classrooms and addresses their needs in terms of district and state standards. Content must include activities appropriate to students at the grade level being addressed, and the teacher must be able to transfer them, with only minor modification, to the classroom.

University faculty often lament about the level of preparation exhibited by incoming students. Taking the long perspective, the most effective way to upgrade the entering students is to become actively involved in assisting their middle and high school teachers develop their own skills in the subject area.

Career-Related Websites

Association for Women Geoscientists: www.awg.org/

Careers, maintained by the American Geological Institute: www.agiweb.org/career/

Openings and links to other lists: www.geosociety.org/science/careers.htm

Resume writing, current job listings: www.geo.mtu.edu/geojobs/

Scholarship listings by organization: pangea.stanford.edu/EEGS/scholarships.html

Women and science literacy: www.aacu-edu.org/Initiatives/scilit.html

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