occupied while a teacher tends to other tasks, such as marking the role or arranging materials, and it is useful to use a cooking timer to ensure the allowed time (e.g., 3 minutes) is not exceeded.

Source: Slater, T. F. (2006). The first three minutes . . . of class. *The Physics Teacher*, *44*, 477-478.

Travelling the Road Beyond the Curriculum Through a Science Fair

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Abstract

In this paper we describe a model for a science fair, within the context of an elementary science methods course. We first describe the theoretical perspectives from which the idea of science fairs derives and we provide definitions as we sketch the characteristics of commonly used science fairs. We then describe the context and processes of a science fair that was organized by a team of university instructors, prospective elementary teachers, school teachers, parents, and friends. We argue that the main contribution of this paper is that it provides a concrete example of a personally meaningful and science-relevant learning experience that combines formal and informal learning activities. The implications of this work are associated with paving the path towards exploring the question, "How can we travel the road beyond the curriculum?" as it provides the basis for intellectual conversations for the place of science fairs in formal education.

Prospective elementary teachers quite often complain that their learning-to-teach experiences in the university are far removed from the reality of the elementary school classroom. In an attempt to address this problem, we engaged prospective elementary teachers in the design and implementation of a science fair, within the context of an elementary science methods course. In our approach, the science fair focused on engaging elementary school students, under the guidance and supervision of prospective elementary teachers, in inquiry-based investigations: posing scientific questions, making observations, designing investigations, collecting data, analyzing data to form explanations, and communicating those explanations to others (National Research Council [NRC], 1996). The design of this science fair was conceptualized through perspectives on informal learning and particularly real-world learning situations.

Real-World Learning Experiences

Many researchers have argued about the impact of learning experiences that occur in out-of-school contexts such as museums, science centers, national parks, zoos, and other informal settings. While much research has been conducted in the area of informal learning within the past decade, it has occurred mostly within museum-like settings (Anderson, Lucas, & Ginns, 2003; Dierking, Falk, Rennie, Anderson & Ellenbogen, 2003). Nonetheless, there is clear evidence to support the notion that there is much learning happening in other "real-world" settings (Wellinghton, 1990). As Dierking et al. (2003) stated, "clearly lacking, though, are comparable studies of learning from film, radio, community-based organizations such as scouts, summer camps, home, friends, the workplace, the Internet, and a whole range of other real-world situations" (p. 109). Adding to this view we argue that also lacking are studies of informal learning within the context of "formal settings" such as teacher-preparation programs. This view actually guided us in designing this instructional intervention; a science fair within the context of an elementary methods course and essentially a community-based approach to science that involves prospective elementary teachers, elementary school students, teachers, university professors, parents, and friends. This real-world instructional intervention suggests the benefits of authenticity for science learning, given that it provides opportunities to experience not only the procedures and tools of science, but also the attitudes and social interactions that characterize science practice (Edelson, 1998).

The Science Fair

Science fair activities are focused on public exhibitions of students' science investigations and their main goal is to encourage student interest in science (Walker, 1992). The science fair can be utilized in the science classroom as an integrative system of formal and informal instructional activities. A review of the literature indicates that science fair has been used throughout the years in a variety of school settings mostly because of its potential to motivate students and facilitate positive student attitudes towards science. Through their engagement in a science fair, young learners are asked to carry out a scientific investigation and present their findings to other young learners or adults who visit the fair. In many cases, there also exist competitions in science fairs for the purpose of enhancing student motivation for participation. In our approach, we place emphasis on the learning of prospective elementary teachers instead of elementary school students, and herein is the innovation of this instructional intervention: a science fair in support of learning to teach science at the elementary school. In designing this science fair, we were exploring ways to provide prospective elementary teachers with learning experiences that were as close as possible to the realities of the elementary school classroom.

Beyond Covering the Curriculum

The design of the elementary science methods course was based on recent recommendations for reform illustrated by the *National Science Education Standards* (NRC, 1996) placing an emphasis on scientific inquiry. The purpose of the course was to support prospective elementary teachers in developing contemporary understandings of science teaching and applying those as they were being developed in practice through the design and implementation of the science fair. The main objective of the course was to support prospective elementary teachers develop a personal philosophy of science teaching and learning based on contemporary theoretical perspectives about teaching science as inquiry while placing emphasis on the role of evidence and explanation in science.

The first half of the course (6 weeks) was what we called the formal science phase of the science fair, as it was associated with formal instruction in the university classroom. During this phase, prospective elementary teachers were guided to develop conceptual understandings about scientific inquiry through seminal readings. Concurrently, outside of the classroom time, the instructor and the teaching assistant of the course made arrangements with a sixth-grade teacher at an urban elementary school to host the science fair in the school's yard. In an attempt to develop a common plan of action and mutual understanding and trust between herself, as a representative of the school community, and the prospective elementary teachers, the teacher visited the science methods course twice during the first half of the course. During her visits, she engaged in classroom activities with emphasis on scientific inquiry while rules of engagement in the science fair were established.

During the second half of the course (6 weeks), each prospective elementary teacher was assigned to either one or a pair of elementary school students and together they had to design and carry out a long-term, inquiry-based investigation. We refer to these activities as non-formal science as these were organized outside the formal system but were incorporated into the formal curriculum (Koliopoulos, 2003).

Procedures of the Science Fair

There were 60 prospective elementary teachers enrolled in the elementary science methods course, and 50 elementary school students from two sixth-grade classrooms, involved in this fair. The students were first asked to form questions that they would like to investigate. These questions were then refined and rephrased by the students in collaboration with the prospective elementary teachers and the teaching assistant in order to form testable questions. The work was basically done at different places in the schoolyard, or at the science lab, during school time and where appropriate arrangements for desks, chairs, and laboratory materials were made. During these times, school teachers, parent helpers, and the instructor and the teaching assistant of the course rotated around the working groups and provided support in the carrying out of the investigations.

Concurrently, the methods course continued to meet at the university while prospective elementary teachers had regular meetings with their instructor and teaching assistant during office hours to discuss design issues of their investigations and report on their progress. Moreover, the instructor and the teaching assistant of the course were in frequent communication with the teachers of the school in order to maintain a record of growth for each team of prospective teacher and student(s). At the same time, parents and other community volunteers were involved in organizing and managing the logistic aspects of the science fair, such as preparing printed invitations for the Ministry of Education, the University, schools, local community, and other organized groups.

The sixth-graders engaged in the investigations through specially-designed curriculum materials that placed emphasis on designing experiments and aimed to support the development of inquiry skills (Constantinou & Learning in Sciences Group, 2004). In general, the investigations involved interaction with, and manipulation of, simple materials, collection, analysis, and interpretation of data, and representation of findings in a variety of formats. The final outcomes of the investigations were, in most cases, a poster which described both the process and findings of the investigations, a related interactive activity, and a game or demonstration associated with the investigation. Examples of investigations carried out at the fair are: (1) What causes a boat to travel faster? (2) What factors are associated with how far a paper plane can fly? (3) What factors are related to the length of a string? (4) What factors affect the length and direction of shadows? (5) What factors affect the pressure of gases? (6) What causes a balloon to float? (7) What factors are related to the growing of plants? (8) What causes a pendulum to swing? (9) How can we help sand concentrate more heat from the sun? (10) Why are different kinds of sounds produced by hitting on different types of bottles?

At the end of the 6-week engagement in investigations, the school organized an all-day public event where each working group of prospective elementary teacher and elementary school students communicated both the processes and the findings of their investigations using interactive posters, exhibits, and demonstrations. We characterize these activities as informal science activities since they were activated outside the formal educational system (Koliopoulos, 2003). The exhibits and demonstrations engaged the public in a specific aspect of their investigation through an interactive activity, scientific experiment, and/or a game. The involvement of the public (i.e., parents and friends) in the interactive exhibits is of immense importance as one of the baseline design strategies of the science fair is to nurture a symbiotic relationship between the university, the school, and the local community.

Evidence of Success

Participation in the science fair was beyond our expectations. The presence of a great number of family and friends of the students, as well as the prospective teachers, provided a sense of community and relevance to science on that day. Teachers, grandparents, young brothers and sisters of the students, and the prospective teachers all participated in scientific experiments and interactive games with great enthusiasm. Beyond the great enthusiasm from all communities that was conspicuous on the day of the science fair, anecdotal evidence from prospective teachers' reflective journals provides support to the notion of success of this science fair. For example, in her reflection statement, a prospective teacher indicated that the science fair, for her as a future teacher, was beneficial because it modeled an innovative way of teaching science, which differed considerably from what is usually observed in an elementary school classroom. This response was typical of the rest of the prospective teachers' statements, which pointed out that the science fair was an exciting and growing experience that brought together the school, the university, and the community and helped them understand how a variety of activities, both in and out of class settings, can support student learning. Other prospective teachers found it exciting that the students decided upon the topics to be investigated, which in turn enhanced their motivation to participate. The main drawback of the science fair, as identified by some prospective teachers, is that it requires a lot of effort and time, which is usually a problem for teachers. Most of the prospective teachers stated that the science fair was successful because a great number of people were involved and they were unsure if they would be able to organize science fairs in the future without the support of their colleagues.

Perhaps most notably, and with rare exceptions, prospective teachers elaborated on the issue of identifying connections between science and society through the design and implementation of the science fair. Also of significance is the fact that all prospective teachers stated that they found very beneficial the opportunities to work closely with elementary school students in the school environment. From our perspective, as teacher educators, the science fair was a success since it achieved its main goal; it provided prospective elementary teachers with an empowering learning-to-teach science experience adjacent to the realities of the school classroom. It became evident to us, both through our own engagement in the science fair and our observations of prospective teachers' participation and analysis of their reflective journals, that the science fair was a growing experience for them as future teachers. The majority dedicated a lot of their personal time to the design and implementation of the science fair as they invested much energy in constructing the knowledge and developing the skills needed to engage students in a variety of inquiry-based tasks.

Concluding Thoughts

Our experiences suggest that designing and implementing a science fair has the potential to be a worthwhile and empowering learning-to-teach experience for prospective elementary teachers as they attempt to find personal relevance in science and construct theories of teaching through their preparation to teach. As we think of better ways of implementing science fairs in the future, we focus our attention on exploring in further detail the potential of going beyond the curriculum and providing prospective teachers with empowering, real-world science learning experiences. Future steps in our work will focus on researching the ways in which engagement in a science fair would be fruitful in proposing a new conceptualization of the nature of science on the premise that science is socially structured as much as science influences the structure of the society (Kuhn, 1962).

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Ideas in Brief

Summaries of ideas from key articles in reviewed publications

Open Days Portray a False Image

Secondary schools in the UK commonly host open days for students from feeder primary schools. While other subjects might exhibit textbooks and examples of students' work, science departments typically focus on portraying science as a fun, exciting, enjoyable, hands-on activity that need not be conceptually demanding and in which "whiz, bang, pop" experiences are usual.

While this may create short-term interest in science, Abrahams (2007) sees it as problematic. By not truthfully portraying "normal" school science, this approach creates unrealistic expectations about the nature of science and an unsustainable image of science, which in turn leads to disappointment in students with the reality of subsequent school science.

Science is the study of the natural world, in which there are limited exciting flashes, pops, and bangs. Also, it is not an essentially hands-on pursuit, and does require engagement of the mind. It would be preferable to show students that the excitement associated with science comes from the intellectually fascinating task of trying to understand nature rather than in merely producing spectacular phenomena.

Reference

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