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# PROMOTING STUDENT RESEARCH WITH SCIENCE FAIRS: CASE STUDIES OF EXEMPLARY PROGRAMS

## Abstract:

There is increased discussion and recognition of the importance of project-based learning in education (Chin & Chia, 2004; Krajcik, Czerniak, & Berger, 1998; Lam, Cheng, & Ma, 2009). Full-inquiry science research projects develop science content and develop and assess all of the standards-based science process skills and inquiry skills. In the dawn of project-based learning moving beyond talk and into implementation, full-inquiry science research should be the gold standard of independent project work.

We propose that policy people, leaders, and teachers have the following three main goals for science fairs: (a) Winning Goal, (b) Quantity Goal, and (c) Quality Goal. These goals may not be explicitly stated but they do shape behavior. The winning goal is common but focusing efforts on elite students doing elite projects may limit the amount of students participating. For this research we selected programs that were exemplary in maximizing participation but yet were interested in quality research.

Case study analyses of science research programs in Costa Rica, Ireland, and Marlborough, Massachusetts were conducted. Interviews of leaders, supporters, and students were conducted. These interviews and supporting documents were analyzed. Each of these case studies is described and conclusions from comparing programs are presented. The research can inform existing science research programs and places seeking to establish science research programs.

## Keywords:

Inquiry, student research, science education

**JEL Classification:** I21, I29

# Catalyzing Involvement in Student Research with Science Fairs: Case Studies of Exemplary Programs

There is increased discussion and recognition of the importance of project-based learning in education (Chin & Chia, 2004; Krajcik, Czerniak, & Berger, 1998; Lam, Cheng, & Ma, 2009). In science education, full-inquiry science research projects develop science content and develop and assess the full range of science process skills and inquiry skills. In the dawn of project-based learning, full-inquiry science research should be the gold standard of independent project work.

## Full Inquiry Science

The term full-inquiry science research applies to situations where the students do all of the following: choose a problem to investigate, learn more about the topic through bibliographic searches and/or talking with experts, propose hypotheses, design investigations, collect data, analyze data, and communicate the results. One of the main purposes of the modern science fair is to give students a place to communicate to others, which is an essential aspect of the full-inquiry science research project. Another important aspect of science fairs is it allows students to interact with and learn from other students and their investigations. The work might be motivated by a science fair, but the work itself is appropriately called student science research.

## Complimentary and Conflicting Goals

We propose that policy people, leaders, and teacher have the following three main goals for student science research and science fairs: (a) Winning Goal, (b) Quantity Goal, and (c) Quality Goal. These goals may not be explicitly stated but they do shape behavior.

Science fairs are typically competitions, and in competitions some people are motivated to try to win. The science fair can motivate some students to put more effort into the science research they are doing. Often for prestige reasons, schools, districts, regions, states, and countries try to improve the quality of the students' science research so that more awards are garnered. This goal is termed the Winning Goal.

A different goal for schools, districts, regions, states, and countries is to increase the participation of students doing science research by encouraging more students to participate. This will be termed the Quantity Goal. In the third goal, the Quality Goal, the focus is on improving the research that students do. It can be simple, such as getting students to move away from making models of volcanoes and towards doing investigations and it can be complex, such as teaching students to use Microsoft Excel to produce t-tests.

We observed the following relationships between goals. The Quality Goal and the Quantity Goal can be advanced together, as can the Quality Goal and the Winning Goal.

The pursuit of the Winning Goal, however, can reduce the quantity because the focus shifts to working with elite students willing to go the extra distance to have high-level projects.

In considering how to improve science education for a citizenry, we regard the Quantity Goal and the Quality Goal as most important. This report describes the results of three case study investigations of three approaches to science fairs that have the primary goals of increasing participation and having students do quality work. The three case studies were done in Ireland, Costa Rica, and Marlborough School District in Massachusetts.

## Methodology

This research employed instrumental case study methodologies (Stake, 2005), which focus on providing detailed contextual analysis of a small purposeful sample that may be generalizable to other contexts, to develop a deeper understandings of factors that led to the success of exemplary student research programs. The researchers developed initial questions for the interviews and one researcher traveled and spent three to five days with each program.

## Results

### Expanding Student Research in Ireland

Ireland had its first Young Scientist competition in 1963. “I think the national science fair program has been one of the most successful programs, you know, in comparison to other national science programs. It has the longevity. It has now established a recognition within Ireland as something that is almost part of our heritage, our gene pool”(Padraig O’Murchu, Ph.D., Education and Research Manager, Intel Ireland).

This elite science fair creates a problem for access. Students submit one-page abstracts and are either among the 520 projects accepted or denied the opportunity to participate in the four-day Young Scientist event held at University College Dublin. “If your only experience of a science fair is: ‘I entered Young Scientists and I got turned down’—its disheartening” (Brian Murray). Since there are no feeder science fairs, one-half a million secondary school students are denied the opportunity to participate in science fairs. They have no chance to share their results, answer questions by judges and interested people, and to learn from other students’ projects.

The solution to letting more students experience science fairs was planned by the Irish delegation to the Intel Educator Academy, which is held in conjunction with the Intel International Science and Engineering Fair (ISEF). The SciFest program created a separate science fair system that used the countries institutes of technology to host the SciFest events. The institutes are post-secondary options for students that are located in all regions of the country. Faculty members at the institutes plan and conduct all aspects of the fair. They are motivated to improve science education, encourage more students to

pursue science careers, and to induce students with an interest in science to consider their institutions for post-secondary study.

The program was piloted in 2006 and then went national in 2009. In 2009 it had 1980 students participating, 2,649 students participating in 2010, and over 3,500 participated in 2011. This year the winners in each region will be brought together for another opportunity to discuss their projects and learn from others and the top project will be sent to Intel ISEF. The top projects in SciFest are very strong, and some go onto the much older Young Scientist competition and do very well.

**Expanding Student Research in Costa Rica**

The University of Costa Rica ran Costa Rica's first National Science Fair in 1987 with between 30 to 50 schools participating. The University continues to run the National Fair today. Costa Rica stands out because their science fair system became national law, voted by the parliament in the 1990s as Law 7169. This law formalized the science fair structure and approximately 300 schools participated each year in the 1990s. A National Decree in 2004 was a declaration for inquiry: Science fairs became part of the National School Calendar and institutional fairs are mandatory. All students have the opportunity and right to present their research in science fairs at the school level. The flow for top-award winning projects is from school level, to district level, to regional level, to the national science fair.

In 2000, an estimated 700 schools participated. In 2004 (the year of the Decree), the number of schools participating swelled to 2,300 and two years later it was 3,400 schools with an estimated 50% of students participating.

**Expanding Student Research in Marlborough, Massachusetts**

Marlborough Public School district is located approximately 30 miles west of Boston. Approximately 30 percent of the students are on free and reduced lunches. There is one high school, one middle school, and three K-4 schools in the district.

There are two things that make the Marlborough science research program special: (a) all students in all secondary science classes are required to do science research projects and (b) teachers provide ample support to the student researchers.

The science research project is not just given to students with the expectation that they will go and do it and bring it back on the due date. Rather, there is an extensive support system. The six main categories of support are as follows: (A) Deadlines for components are clearly communicated; (B) Some class time is used for the science research process; (C) Teachers review submitted components and provide feedback to students; (D) If needed, students are given help coming up with projects; (E) Special science materials for the projects are ordered and paid by the school; (F) Teachers spend time outside of class helping students with their projects; and (G) Research Packet guides the process.

A student described her view of the science research process: “The teachers help you out a lot with the different steps of the projects. And it’s structured very well so that you can focus on different parts of your project and it makes it very easy to get through it and do your research.”

## Discussion and Comparisons

Each region had a focus on the Quantity Goal and Quality Goal: increasing the quantity of students engaged in quality science research that they would present at science fairs. While the leaders in these programs liked the idea of students winning awards, the main focus was not the Winning Goal. There was, however a desire to keep improving the quality of projects.

The programs in each region benefited from forethought and planning. In each case, key people attended the Intel Educator Academy, made plans, and executed the plans. Subsequent visits to the Educator Academy helped the programs improve upon existing practices. In each case, professional development of the teachers was seen as an important aspect of science research and science fair programs.

Ireland and Costa Rica as entire countries with similar population sizes make for interesting comparisons. In Ireland the SciFest system became an entirely different entity than the existing national science fair. In Costa Rica, a feeder fair system to the national fair was used to enhance science fair participation. In Ireland, SciFest is not a government entity, although it does receive support from a government-sponsored agency (Discover Science and Engineering) and the government does not pay the director. In Costa Rica, the science fair system is a government entity, although it does receive corporate assistance.

In both Ireland and Costa Rica, the programs are run by one woman in a salaried position. This person coordinates everything that happens at the national level. They have no paid staff to assist them but they do have volunteers around the country to help and they receive input from different groups. In both countries, the feeder fairs are run at the regional and local levels. The leaders in these programs are very capable people who have been successful. Because there is an established salary position with the sole responsibility of coordinating the science fair, in future years, it is highly likely that successors will continue the science fair work.

In Marlborough, an energetic and charismatic department chair helped build the culture of science fairs. There is no specified position that focuses exclusively on science fair; it is something that the leadership and teachers do together. The former department chair has recently transitioned into a new role, and with new departmental leadership there is no guarantee that the program will continue.

The Marlborough method, however, can be seen as a building block for other programs, including Ireland and Costa Rica. The best way to maximize participation in student-research projects is to make it part of the curriculum and part of science courses. Generalities were drawn from case studies to describe the following commonalities: a strong team, inspired planning time, an action plan, and a leader.

**Strong Team**

Achieving high levels of student participation in science research is a cooperative endeavor. At the school-district level, key players might include decision makers like district leaders, as well as science, technology, engineering or math (STEM) coordinators; principals; teachers; parents; community members; and students. Committees are formed to address all facets of science fair participation including planning and logistics, judging, and awards. In expanding science fairs to larger groups and geographic areas, teams need to address these facets at a larger scale, incorporating more localized committees into the mix.

What type of team is necessary to initiate a broad science research program across a state, province, or country? The answer is clear: there needs to be Ministry of Education/government officials who can make decisions, as well as representatives of STEM organizations, and teacher leader/advocates who have ample experience with science research and science fairs.

**Inspired Planning Time**

Highly effective action plans have been written at the Intel Educators Academy, a one-week event held in conjunction with Intel ISEF. During the five-day period there are whole-group presentations, smaller sessions where participants choose workshops of interest, informal discussions with other teams, and participation in Intel ISEF activities including the opening ceremony, walking the exhibit floor, and the closing ceremony. A key component of the Intel Educator Academy, however, is the sheltered work time where participants develop, discuss, and revise their action plans. Getting the right people to the table and having them think and converse deeply about student research and science fairs leads to strong implementation plans.

**Action Plan**

Strong plans for science research programs include an accurate representation of the current status of the program as well as a vision for where the program is heading. This must be coupled with clearly articulated and feasible steps to completion, including, who is going to do what and by when. Short-term plans and goals keep the project moving forward and provide focus. While long-term vision is important, action plans for one year in length are effective because of their immediacy and specificity. At the end of the year, achievement is evaluated and new plans can be created. A strong component of the Intel

Educator Academy is that after creating plans, the teams share them with other teams. This motivates them to prepare solid plans and as they work on their presentation, they self-evaluate, revise, and amend the plans. Hearing about other plans can also inspire further improvement. Finally, presenting the plans gives participants an enhanced sense of ownership and enthusiasm.

### Strong Leader

Strong leaders guide the implementation of a strong plan with a strong team. These leaders have credibility, enthusiasm, and excellent organizational skills. Their credibility comes from significant experiences in schools facilitating student research and participating in science fairs. Science fairs are large undertakings that rely on many volunteers and lots of work. Enthusiasm is the engine that keeps moving the project forward. With the many moving parts, such as different committees, meetings, timetables, and needed changes, a strong leader needs organizational skills to keep up. Finally, a good leader also cultivates a climate of mutual accountability so that all participants work together to achieve the goals set forth in the plan.

## Conclusion

As project-based learning moves into secondary schools, the project that helps students learn content and all the key inquiry skills is full-inquiry science research. Science fairs can play an important role in these projects because they are an ideal venue for students to communicate their results, learn about other student projects, and increase student motivation to do research. In the three case studies reported, three different approaches were used. In each case the goals were for more students to do quality research and have valuable experiences sharing and celebrating their research. Each program was successful in meeting these goals.

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