Guidelines and Suggestions for Science Fair Projects

The Ongoing Nature of Developing this Guide

In this draft document, we describe the features and processes of the science fair project. We arrive at these suggestions and guidelines through our own research, reading, judging regional and school science fairs, and experiencing two full life-cycles of science fair projects. As with all other suggestions we make, these ideas need to adjust and fit with the individual classroom situations. There are some project features which we feel are essential, and we try to emphasize them as such.

We intend this document to serve two purposes: 1) as a starting point for our discussions, preparations, and planning for this year's science project efforts; 2) as a living document to be expanded, modified, and specified during the year. This present draft only reflects the views of the research side of the team. We hope that ongoing drafts would be a converging consensus of the whole team.

Presently, only the early stages of the process are in suggested in detail. The latter stages depend so heavily on the progress of the early stages that providing implementation details could be premature.

Goals of Science Fair Projects

To help students pursue a personally meaningful inquiry by awakening their initiatives and interests, developing their project management and follow through, and encouraging them to articulate their progress and findings to peers, parents, and the broader public.

Key Features of the Science Fair Project

- Students must be the ones to take the initiatives in choosing the project and following through (with teacher's guidance) to the end. The project concepts must, from the beginning to the end, reflect deeply the students' own values, identity, and voice. Without it, this effort will likely continue to disengage those students who are already disengaged from science.
- The teacher helps to make the projects a continuous presence in students' minds, in the classroom and school environment, and in teaching. The teacher makes the projects an integral part of school science, rather than merely an extracurricular activity. Without it, it is unlikely that any benefit (of engagement, of interest, of skills) will trickle from the projects into regular classroom instruction.
- Students are held accountable by public and private presentations to the teachers, their peers, their parents, the school community and community at large. While grades may still be a necessary component of accountability system for the students' projects, we believe that a stronger form of accountability exists in the public nature of their work.

Stages of Implementation

Here, we outline the necessary stages of implementing this project process. However, we recommend that, within logistical possibility, to allow different students to progress through the stages at a varied pace. The mile-markers for each stage can be set at fairly generous intervals, allowing the more ready students to go ahead whenever they are ready, but also enabling extra help for the needier students to keep pace. Between stages, there needs to be milestones and checks. Perhaps not all the students can complete all the stages successfully and in time, but we suggest that it is better for a struggling student to complete one or two stages well, than to rush through all the stages poorly. In this project, we believe it is essential to help the students to engage in the process for as long as possible, no matter how well or poorly they are doing. It is meant to provide for the students something that is "their choice", not an external mandate of what they need to learn; and that they need to exercise continued control and responsibility to make the project into something they want it to be.

Stage One: Forming a Project Concept

The keyword here is "invest". Invest heavily into students' search and selection of the project concept. In all of our past observances of school science fair, we have felt that this stage is most under-invested when there is a time crunch. A substantial investment here not only pays off in the long run, but is essential for the project to even have a chance at being successful for the "non-science" students.

Indicators of a successful project concept formation

- Students "owns" their project ideas, evidenced by their level of excitement, interest, curiosity, and anxious expectations.
- The project idea is "researchable", yet not so confined that it is simplistic and irrelevant to the real world.
- The project idea allows room to be innovative, creative, and meaningful and does not have easy pre-drawn conclusions.
- Milestone check: a draft research proposal, containing the description of the idea, its motivation and rationale, and discussion of potential usefulness of the finding. Students should know up-front that they will be presenting the projects to peers and community.

In terms of "owning" the projects, we mean more than students saying, "Oh, this is fun." We have seen students rushing into a start by selecting pre-canned or "recipe" science projects from books or the Internet, and quickly losing steam as the procedures become more complicated or less predictable than they had imagined. It is very easy to give up on something that is not truly "yours". We have also seen many students taking an easy way out, choosing what is easily "doable" over what is deeply meaningful. Consequently, year after year, we see a lot of consumer product projects, comparing one perfume against another, one lipstick against another, one detergent against another. While these projects can be well done, they often lack room for true creativeness or ongoing excitement of discovery. Here're some examples of initial project concepts that shows true sense of personal ownership. In this instance, we had asked students to create projects along the theme of "nature vs. nurture" while teaching a unit of heredity.

- Looking for hereditary and environmental causes of diabetes because the student's entire family, in three generations, is stricken with the disease.
- Looking for non-hereditary causes of asthmas because the student is the only person in the family who suffers from it.
- Looking for heritability of facial and other features because the student looks very much like his mother and thinks he will grow up to be more like his mother (his mother had just passed away a few years earlier).

To bring about such meaningful personal investment takes a lot of patience, guidance, and encouragement from the teacher. Some students arrive at this quickly. Most struggle with this open-ended task. We believe that it should be made very clear to the students early on that this project is "theirs" and they have entire responsibility over it. The project has to reflect their unique understanding, personality, interest, and situation.   The question posed and the anticipated result needs to "matter" first of all to the student himself or herself. In addition, the question and the result need to have the potential to "matter" or to "benefit" other people as well. It can be difficult for students to find where to start. Some suggestions on general categories and types of questions (e.g., "Why does … do that?" "How does the environment shape …?"), sample project ideas (we can provide that), or broader suggestions of field (e.g., Health, Human Behavior, Technological impact on human and society) are definitely helpful. But students really have to get away from the idea that they are to select from a pre-approved list of canned projects. We believe the form of guidance the teacher can offer at this stage is to ask the students a lot of questions in the spirit of "let me help *you* find and do what *you* want to do", as contrast to, "let *me* find you something that you *can/should* do". Interestingly, we've found many students initially resist this new freedom much more than teachers do. The needy students really just want to be told and given a project, rather than to search for a meaningful one on their own. Taking the time to provide the needed guidance, often one-on-one, can aid greatly in this process.

In terms of identifying well-specified questions that are "researchable", we believe there is a balancing act. Too well specified questions may be too narrow and uninteresting. Too vague questions may initially engage the students, but offer little clue as to how to approach. Often, the non-science students in the classroom tend to come up with ill-specified questions. For example, last year, we had several students who claimed to want to investigate, "Is the world coming to an end?" We then had to push them to specify and narrow down to issues of war, poverty, or environment. Some good examples of interesting and researchable questions from past science fairs are:

- Finding out and test ways to reduce the severity of asthma attacks despite having the disease since birth.
- Finding out what distractions (among food, cell phone, or passenger) most impede a driver's concentration on the road.

- Do people on the street react differently to the same child in different types of clothing? (e.g., school uniform, gothic, etc.)
- Are adults and children equally capable to detecting truths and lies in another person?

Finding a concept that has potential or "room to grow" is closely related to the "researchable" and "defined-ness" of the concept. But for any project to grow, the student has to take on the challenge. For example, take a narrowly defined project of comparing detergents to see which one cleans best. Typically, that project would conclude, "Detergent A cleans better than B and C." But if the student gives attention to finding a reliable way to define and measure "cleanliness", it may present innovations on the research methods. Or, if, after drawing the simple conclusion, the student spends much time finding out *why* one detergent is better than another. Likewise, take a very vague project concept, "Would the world come to an end through wars?" The student has no idea how to proceed except to guess wildly the wars of the future. But prompting him to ask, "To know if the world would end in war, you need to understand why war happen in the first place." This can then lead to an investigation of the origin of human violence within our species, a much more interesting, defined, and challenging question than the vague one before. In general, we have found many projects, in schools or at city-wide science fairs, tend to spend much time on describing the phenomenon, or, the "how" or "what happened" in the project, and spend very little time on discovering the "why" behind the phenomenon. The "room to grow" of most project really lies in the pursuit of the "why" question. This, no doubt, can be very difficult for students (and adults alike). We suggest that it is worth pushing for, even if the final results fall short of ideal.

Deliverable for Stage One

The deliverable product from this stage is a project concept proposal, complete with the research question, its rationales and motivations, and the projected meaning (benefit) of the findings. The students should be able to answer, "Why does this matter to me?" and "Why does this matter to other people and the world?" The drafting of this proposal can go through at least one iteration, allowing the teacher to provide feedback. In addition, select students can present their project idea with the whole class to both role-model and to get critique and feedback from their peers. We anticipate a lot of one-on-one attention from the teacher to the students would be needed at this stage.

Here're two examples of such concept proposals, one very specified and one broader. These are actual examples drawn from students' presentation and writing about their projects.

Concept A. Ways to Reduce Asthma Attacks

Description: I want to find out ways to reduce asthma attacks for myself. I want to know what are the things I can do, I can eat, or I can change about my surrounding that can make my asthma better. I also want to know which of these things are more effective than others.

Motivation: I want to do this project because I have asthma ever since I was born. But nobody else in my family has it. So a lot of times my family doesn't know how to really help me. I have someone in the family who smokes, and I feel worse whenever there is smoking. But I don't know how I can convince them that my asthma can be made worse by smoking. Also, sometimes asthma passes from parents to children. So maybe my children will have it. I want to know how I can help them too.

Benefit: It would definitely benefit me to under my asthmas better and know how to improve my condition. But if I really find out something useful, I think it can help other children who suffer from asthma as well.

Concept B. Is our fate in our genes?

Description: I want to know what can be inherited in our genes and what we can do about it. I am thinking about things like intelligence, drug addiction, and other things. Some will help us to be better. Some makes us worse. But is our fate in our genes?

Motivation: I just thought that we need to know how much of our fate is already decided by our genes. I want to know if there is anything we can do about it. If someone doesn't feel so smart, does that mean he is always going to be dumb no matter what? If someone is on drugs because his mother or father was on drugs, does that mean he cannot change it?

Benefit: I think it would help myself and many other people to understand something about their genes. I hope to know that genes don't control everything and that there's still something we can do about ourselves.

Note. Of course, a project like Concept B would take more guidance from the teacher, hopefully to help narrow down to one trait (e.g., intelligence, temperament) rather than a broader statement. However, as a concept, this has a lot of room to grow and explore.

Stage Two: Planning the Research

The planning follows the formation of the project concept and in some sense runs through the end of the project, as the plans are "re-planned". Once students arrive at the draft proposal stage, they do need a lot of help (maybe in a whole class format) on developing a research method. This is where the more traditional descriptions of "inquiry" or "scientific process" come in. In place of just "experiments", we refer more broadly to "data collection", where data means generally any necessary information you need to answer the research question. Such data may include the traditional experimental outcomes and measurements, but they could also take the form of observation notes, interview notes, survey results, review of other people's work and results, summary of published reports, and so on. Regardless of the choice of methodology, students should be expected to do the following:

1) *Define what data one needs to answer one's inquiry*

Now that the students have an idea "what they *want* to know", it's time to decide "what they *need* to know". For example, if one is studying what distracts drivers the most, she needs to know what the common distractions for drivers are (e.g. review reports, interview or survey drivers); she also needs to know how demanding the driving process is, what drivers need to pay attention to (e.g., staying in lane, other cars, traffic signs); she then needs to get some data on what happens when drivers are distracted (e.g., survey of drivers, traffic accident records, simulating driving with a computer driving game, which, by the way, a student actually did and did well.)

2) Testing the data collection methods

It is important, in the planning stage, for students to have some sense of the feasibility and usability of their proposed methods. For example, if a student designs an experiment that would eventually need 10 people, he probably should try it with one person first. If a student designs a survey, she probably should run the survey by a few people and make modifications. Pilot-testing their procedure may be a good and concrete milestone to set for the students. The criteria for pilot-testing will need to be set per individual case. For one student, it may be, "try that experiment once"; for the other, it may be, "interview at least one person first".

3) *"Does it make sense?"*

As data is being defined and collection methods designed, it is important to check and double-check to make sure that the research question, the data needed, and the methods of collection are consistent with each other. Good questions to ask students (and preferably, for them to ask themselves and each others) are, "If you want this data, is this the right way to get it?" "If you have this data, how would it answer your question?" "How do you expect the result to turn out? If it turns out this way, what would that mean to you? If it turns out the other way, now what?"

Deliverable for Stage Two

At the end of this stage, a full research proposal should be ready, containing the goals of inquiry, data needed, and methods of collection. Included in this proposal should be preliminary artifacts of pilot-testing of the tools (equipment, survey forms, interview questions, whatever applicable).

Here is an example of how the previous Concept A (in Stage One) should be expanded to look like at this stage.

Goals of inquiry: … (similar to the concept proposal)

Data needed: I need to know what are the factors that can make asthma worse, like smoking, or dust, or too much physical exercise. I also need to decide how to measure asthma attacks and describe how bad it is. Then I need to decide how to find out if a change in my habits or living condition is effective or not.

How to collect the data:

1) For a week, I am going to keep an asthma journal with me. Every time I feel bad or have an attack and have to use an inhaler, I am going to write down as much about my activities and environment as I can. Then I can go through the notes and find out what some of these attacks have in common.
2) If I find out that someone smoking nearby often makes my asthma worse, then I can decide that is one of the factors. I guess the change I can make is to ask the person not to smoke. If they don't stop, then I'll make myself leave the place. If I do this quickly, my asthma attack may not happen or may just happen a little bit. I will do that consistently for two weeks, and see if asthma attacks related to smoking have reduced. I may find another friend who has asthma and asked her to do the same thing.
3) I need to decide how to keep track of asthma attacks. I looked up online and saw that you can use a scale, from 1 to 10, to say how bad it is. You can also record how long it took for breathing to be normal again.

Artifacts to turn in: A sample of the asthma journal, and the scales used to record attack severity.

Note. When reasonable, this proposal can be fleshed out and have more details. However, this example has the gist of the kind of information that should be included.

Stage Three: Conducting the Research

With the two stages, some students may be well into the execution of the research while others are still in planning. When logistically feasible, this should be allowed. It may be unproductive for any student to proceed with research when their planning is obviously inadequate and flawed.

One key aspect that may help in this stage is the requirement to communicate. Here're some suggestions.

1) Students need to produce periodical progress report on the research.
2) When the students' work overlaps classroom teaching content, select students could be asked to present their progress in regular class time.
3) The students who are particularly advanced on their projects should have opportunity to present to the full class to set a role model example of how the projects can and should be conducted.
4) Peers should be encouraged to comment, compliment, and critique projects along the way. The more the peers critique, the less the teacher has to.

Our limited experiences show that students do take presentations seriously, and that other students pay attention to such presentations. In one school where we did this type of presentation and Q&A sessions, the quantity and quality of the audience questions to the presenters were astonishingly good. The presenters' responses to novel questions were equally remarkable. For now, we will not dive into details of this stage. Much of it depends on the success of the first two stages and the specific classroom situation at the time. We can work this out at a later date, when the situation becomes more concrete.

Stage Four: Presenting the Research

We do recommend that the students have public opportunities for presentation and feedback. We envision that it could happen at four levels.

1) One-on-one: students need to present and share their ideas with the teacher, and with their peers in small groups, throughout this process.
2) One-to-class: as the students progress and become ready, students should have the opportunity and obligation to present in front of the whole class. The presentation does not to be about the final product. Any milestone along the way should be suitable. Presentations does not need be done all at once, but spaced out nicely over weeks or months. (In fact, student audience lose their attention when presentations are done several days in a row.)
3) One-to-school: if possible, a school level event which invites parents, teachers, and other students should be made available to showcase the first iteration of the complete project.
4) One-to-public: Students should keep in mind that, as they wish, their work, after presentation and revisions, can go as far as the Sci-Tech festival and be formally viewed by judges and other schools.

Details of this stage can be determined in detail as we implement these. We do feel strongly that the public nature of their work holds more weight in accountability for the students than grades alone.