Overview and Key Findings from the Science Fairs Under the 'Scope Study

About the Data Collection

We collected data from middle school science fairs held in schools across the country to understand:

1. What are the basic models and elements of middle school science fairs;
2. If and how science fairs increase students' interest in science, technology, engineering or math (STEM) and/or STEM careers;
3. If and how participation in select models of middle school science fairs enhance students' mastery of the science and engineering practices; and
4. What costs and resources are required to implement an effective middle school science fair?

In order to answer Question 1, in 2014 and 2015, we collected 185 surveys from science fair coordinators, most of whom were science teachers. These science fair coordinators were sampled from a nationally representative sample of 325 middle schools, resulting in a response rate of 57%. The survey allowed us to describe the variety of science fair models taking place in middle schools across the country.

In order to answer Questions 2-5, we collected data from 21 middle schools located in the Midwest, Northeast, South, and Western regions of the United States. These schools were in rural, suburban, and urban locales, with students representing a range of demographic characteristics. Data collected included the following:

Type of Data	**# of Responses and Data Source**
Time queries (surveys completed on a regular basis documenting time and money spent on the science fair)	762, from teachers, principals, and parents
Surveys	185, from teachers and parents
Interviews	206, with teachers, principals, science fair judges, and others
Science fair observations	20
Student focus groups	19
Student pre-science fair questionnaires	568
Student post-science fair questionnaires	537
Science fair artifacts	20 schools provided artifacts

Our study findings, summarized below, describe variation in science fair approaches, student outcomes of learning and interest, parents' involvement in science fairs, and the cost of implementing science fairs. More elaborate and detailed presentations of our findings in response to the questions we posed can be seen in the papers authored by our study team that are listed at the end of this summary.

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Study Findings

MODELS AND ELEMENTS OF MIDDLE SCHOOL SCIENCE FAIRS

Overall, our results indicate that mandatory science fairs were far more common in middle schools than voluntary fairs, and science fairs varied in the types and extent of support teachers provided for student investigations. However, schools with high proportions of African American students are more likely to offer mandatory fairs with low levels of teacher support. Prior literature suggests that teacher support for performing investigations in classrooms is important for deeper student learning. Therefore, these results have implications for providing high quality and equitable opportunities for all students across science fair experiences.

- **We found three primary types of science fairs:**
    - mandatory fairs with high levels of teacher support for students' investigations (23%),
    - mandatory fairs with low levels of teacher support (57%), and
    - voluntary fairs (20%).

- **Teachers were more likely to provide basic support for students' science fair projects** (i.e. choosing a topic, monitoring progress, and general support), compared to more substantive support related to students' *investigations*, such as designing their investigation, collecting or analyzing data, interpreting results, and preparing presentations.

- **Mandatory fairs with low teacher support had higher average proportions of African American students**, $F(2,175) = 4.12$, $p = .018$, **but were also more likely to endorse a learning-related goal as their top goal for the fair,** as opposed to an interest-related goal, $\chi^2(2) = 7.96$, $p = .019$. Prior literature suggests that teacher support for performing investigations in classrooms is important for deeper student learning. Therefore, these results have implications for providing high quality and equitable opportunities for all students across science fair experiences.

SCIENCE AND ENGINEERING PRACTICES

Our analysis of changes in students' understanding of science and engineering practices (SEPs) provides evidence that when students are called upon to synthesize their work in order to prepare themselves and their peers for presentations, they are more likely to demonstrate gains in their understandings of science and engineering practices.

- **In schools where teachers provided a high level of support for students to communicate about and evaluate their work, such as providing opportunities for students to practice presenting prior to meeting judges, students were more likely to show gains in their understandings of SEPs.** We categorized the ways in which teachers supported students' development of the science and engineering practices into three groups: support for investigating practices, for sensemaking practices, and for critiquing practices, and we created categories to describe the amount of support provided as low or high. Associations between students' posttest SEP scores and high levels of these three types of support were tested, and results showed that while neither support for investigating or sensemaking practices were significantly associated with posttest SEP scores, support for critiquing practices was significantly associated with posttest SEP scores $B(SE) = 0.10(0.04)$, $t(14) = 2.46$, $p = .027$.

- **Controlling for other factors, students who participated in science fairs where they were able to present and defend their work and/or critique other students' work made greater gains in SEP scores**. Within this same analysis, we also tested associations between posttest SEP scores and three types of enactment of SEPs in the science fair: *enactment of investigating practices* (if students had the primary responsibility for developing the topics, questions, and plans for their investigations), *enactment of critiquing practices: communication* (if all students had the opportunity to present their projects and respond to questions about them), and e*nactment of critiquing practices: evaluating* (if students were encouraged to evaluate their peers' science fair projects and ask questions about their work). While *enactment of investigating practices* was not significantly associated with posttest SEP scores, *enactment of critiquing practices: communication* was a significant predictor of posttest SEP scores, $B(SE) = 0.10(0.04)$, $t(13) = 2.54$, $p = .025$, as was *enactment of critiquing practices: evaluating*, $B(SE) = 0.11(0.03)$, $t(13) = 3.19$, $p = .007$.

- **African American and Hispanic students showed slight declines in their understandings of science and engineering practices after the science fair; however, more research needs to be done to fully understand and interpret this finding.** An examination of associations between student-level covariates and posttest SEP scores showed that, among racial/ethnic categories, being African American was a significant predictor, $B(SE) = -0.09(0.04)$, $t(315) = -2.61$, $p = .009$ and being Hispanic American was a marginally significant predictor, $B(SE) = -0.05(0.03)$, $t(315) = -1.86$, $p = .064$ of SEP scores.

COST OF SCIENCE FAIRS

Our cost analysis examined the cost in US dollars of implementing a science fair, and the relationship between equity and cost. We examined fairs at two different schools with different approaches and found that:

- **Teachers' time supporting students represented approximately half to three quarters of the total per-pupil costs**: $227.03 per student for teachers' time at School A and $33.98 per student for teachers' time at School B.

- **Teachers wanted all students to have an equal opportunity for a productive learning experience regardless of their families' access to resources**, and so they were intentional about the time they devoted to supporting their students' science fair experiences.

- **Between one quarter to one half of the time that teachers devoted to science fair-related activities was their personal, non-work time.**

- If schools want all students to have equal access to an authentic science fair experience and the support needed for that experience to be a positive one, **the time teachers need to adequately support their students' learning must be anticipated and built into the implementation plans**.

PARENT INVOLVEMENT IN SCIENCE FAIRS

Our data show that parents' views about science fairs are varied and more positive on the whole. Moreover, parents' income and education affect their level and type of involvement, as do certain features of the science fair itself, all of which have implications for science fair design and equity in school-based science fairs.

- **Parents who responded to our survey were positive about the science fair experience.** Our parent survey included items that focused on parents' attitudes towards the science fair, and asked parents to describe the fair using three words. Only 7% of parents responded with only negative words, while 46% of parents responded with only positive words, and an additional 46% responded with a mixture of negative, positive, and/or neutral words.

- **The vast majority of parents who supported their students' project focused on managing the work, rather than performing the project.** The survey data showed that 31% of parents offered *only* logistic support (e.g., helping students manage their projects in terms of time and staying on task, purchasing materials, or providing emotional support) to their children, and 1% of parents offered *only* substantive support (i.e., academic support). A slight majority of parents, 57%, provided both logistic *and* substantive support, and 11% of parents reported that they provided no support at all. In schools where the science fair was mandatory, approximately half of parents provided substantive help, but in schools where the science fair was voluntary all parents provided this help.

- **High-income parents were significantly more likely to provide substantive support to their children compared to mid-income parents**, χ^2 (1, N = 59) = 5.85, p = .016, and to low-income parents, χ^2 (1, N = 69) = 0.65, p = .422.

SCIENCE INTEREST AND IDENTITY

We examined the association between student gains in science interest and two characteristics of science fairs: opportunities for student agency within the science fair, and an emphasis on competition; and whether these characteristics have different effects for boys and girls. We rated school science fairs as having a low or high emphasis on competition, and low or high opportunity for student agency in conducting their investigations (e.g., choosing one's own topic and designing the investigation), showcasing (presenting one's work to a larger audience), and evaluating (providing feedback or critique of peers' investigations). To look at science interest and identity, we measured students' science *career interest*, *desire to do science* in school, and science *self-concept* before and after the science fair experience.

Our results showed that both opportunities for student agency within the science fair and an emphasis on competition were related to gains in students' science interest and identity, but importantly, these relationships varied for girls and boys.

- **Career interest: boys participating in a science fair with a high emphasis on competition maintained their interest in science careers compared to boys who participated in a science fair with a low emphasis on competition. In schools with a low emphasis on competition, boys' interest in science careers decreased.** For girls, none of the hypothesized predictors were associated with posttest career interest, controlling for pretest scores. For boys, however, agency in showcasing had a marginally positive association with posttest career interest, *B(SE)* = 0.23(0.13), *t*(15) = 1.83, *p* = .088, and competition had a significantly positive association, *B(SE)* = 0.26(0.12), *t*(15) = 2.26, *p* = .039.

- **Desire to do science: girls who had the opportunity to present their science fair work to a larger audience decreased less in their desire to do science compared to girls who did not have that opportunity.** For girls, agency in showcasing had a significant positive association with posttest desire to do science controlling for pretest scores, *B(SE)* = 0.24(0.10), *t*(15) = 2.28, *p* = .037, and agency in evaluation had a marginal negative association, *B(SE)* = -0.22(0.11), *t*(15) = -2.05, *p* = .059. For boys, competition had a marginally positive association with posttest desire to do science, *B(SE)* = 0.35(0.19), *t*(15) = 1.82, *p* = .089.

- **Self-concept: girls who had greater agency in choosing their science fair topic and designing their investigation maintained their self-concept in science compared to girls who had less agency in these matters, whose self-concept in science decreased.** For boys, none of the four predictors were significantly associated with posttest self-concept controlling for pretest scores. For girls, agency in investigating was significantly associated with posttest self-concept, *B(SE)* = 0.26(0.11), *t*(15) = 2.39, *p* = .030.

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