Synopsys Outreach Foundation Student Science Fair Project

Evaluation Report

Jennifer S. Mullin, Ph.D.
Steve Schneider, Ph.D.
Mark Loveland, Ph.D.

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Executive Summary

Synopsys Outreach Foundation (Foundation) contracted with the Science, Technology, Engineering, and Mathematics (STEM) group at WestEd in early 2012 to conduct an evaluation of their funded student science fair projects in Santa Clara County, California. The Foundation has a long history of providing support to K-12 educators, mostly in the form of science fair materials (e.g., presentation boards, awards, etc.), with the aim of promoting students’ scientific inquiry and investigation skills through participation in a science fair project. The majority of educators and students served through these efforts come from schools with limited resources, specifically in the areas of science education. While the Foundation has served a critical need in these communities, little work has been done to determine the impact these activities have on a range of student outcomes, particularly in terms of 21st century skills such as critical thinking, collaboration and communication.

Educators from Santa Clara County who received support from the Foundation in the 2011-2012 academic year were asked to administer an online survey to students in grades 4 through 12 during the month of May 2012. Three online student surveys were developed for the purposes of the evaluation: (i) an Upper Elementary Student Survey for grades 4 & 5, (ii) a Middle School Student Survey for grades 6-8, and (iii) a High School Student Survey for grades 9-12.

The overall findings of this evaluation show that the project-based science fair activities increased student learning in science and in a wide range of 21st century skills such as critical thinking, communication and collaboration. Results of the student surveys clearly indicate that students in grades 4 through 12, who participated in the Synopsys Outreach Foundation funded science fair projects in 2011-2012, reported high levels of engagement in their science fair projects. The survey data also shows significant gains (p < 0.01) in several important categories including their abilities to: manage a project and meet deadlines; develop an idea, plan and conduct an experiment; keep a logbook, analyze data, and create a chart or graph; write results, create a presentation board, discuss and present results to an adult other than their teacher.
Introduction

Synopsys Outreach Foundation contracted with the Science, Technology, Engineering, and Mathematics (STEM) group at WestEd in early 2012 to conduct an evaluation of their funded student science fair projects in Santa Clara County, California. The Synopsys Outreach Foundation (Foundation) has a long history of providing support to K-12 educators, mostly in the form of science fair materials (e.g., presentation boards, awards, etc.), with the aim of promoting students’ scientific inquiry and investigation skills through participation in a science fair project. The majority of educators and students served through these efforts come from schools with limited resources, specifically in the areas of science education. While the Foundation has served a critical need in these communities, little work has been done to determine the impact these activities have on a range of student outcomes, particularly in terms of 21st century skills such as critical thinking, collaboration and communication.

Educators from Santa Clara County who received support from the Foundation in the 2011-2012 academic year were asked to administer an online survey to students in grades 4 through 12 during the month of May 2012. Three online student surveys were developed for the purposes of the evaluation: (i) an Upper Elementary Student Survey for grades 4 and 5, (ii) a Middle School Student Survey for grades 6-8, and (iii) a High School Student Survey for grades 9-12. A total of 1,600 students in Santa Clara County, who worked on a science fair project and participated in a science fair in the 2011-2012 academic year, completed one of the three online student surveys. Results of the student surveys are encouraging on many levels. It is clear that students in grades 4 through 12 who participated in the Synopsys Outreach Foundation funded science fair projects in 2011-2012 showed overall high levels of engagement in their science fair projects. Students reported significant gains (p < 0.01) in several important categories including their abilities to manage a project and meet deadlines; develop an idea for an experiment, plan an experiment, and to conduct an experiment; keep a logbook, analyze data, and to create a chart or graph; and their abilities to write results, create a presentation board, discuss and present results to an adult other than their teacher. These findings are important in that they highlight the potential of the project-based science fair activities in improving student learning in science and a range of 21st century skills such as critical thinking, communication and collaboration.

Through a series of discussions between WestEd and Synopsys Outreach Foundation, the following evaluation questions were developed.
Evaluation Questions

1. Where do students get ideas for their science fair projects?
2. How much time do students spend working on their science fair projects and where did they do most of this work?
3. What are students’ experiences with teamwork and collaboration in their science fair projects?
4. Do students who participate in the Synopsys Outreach Foundation funded science fair projects report improved project and time management skills?
5. Do students who participate in the Synopsys Outreach Foundation funded science fair projects report improved scientific investigation, analysis, and communication skills?
6. Do students who participate in the Synopsys Outreach Foundation funded science fair projects report improved understanding of what scientists do and their ability to conduct independent scientific investigations?
7. What do students report as being the best, the most surprising, and the hardest things about their science fair projects?

Synopsys Outreach Foundation

Founded in 1999, the Synopsys Silicon Valley Science & Technology Outreach Foundation supports K-12 teachers and students in California to develop science projects and participate in science fairs. The Synopsys Outreach Foundation (Foundation) offers a program of teacher support and training, support to schools for materials and equipment, and incentives for teachers and students engaged in project-based learning at K-12 public, private and not-for-profit schools in California as well as to select schools affiliated with regional offices of Synopsys, Inc. By 2011, the Foundation has grown to support over 130,000 students and teachers annually, primarily in the Silicon Valley.

The Foundation serves as the major sponsor of the Synopsys Silicon Valley Science and Technology Championship, the regional fair for students in Santa Clara County, California. The Foundation also presents scicencepalooza!, a science fair for students in the East Side Union High School District of San Jose, and sponsors a program of school-based fairs for elementary and middle school students called science-o-rama! The Foundation serves as the major sponsor of programs including the Advanced Science Research Facility, the Advanced Science Research Class, SuperSchool teacher training seminars, the i 3 (initiate. investigate. innovate.) program, the Synopsys Outreach Foundation n + 1 Prize, the Green + 1 Challenge, and Science Fair 101 for Parents.
Methodology

Educators from Santa Clara County who received support from the Foundation in the 2011-2012 academic year were asked to administer an online survey to students in grades 4 through 12 during the month of May 2012. Three online student surveys were developed for the purposes of the evaluation: (i) an Upper Elementary Student Survey for students in grades 4 and 5, (ii) a Middle School Student Survey for students in grades 6-8, and (iii) a High School Student Survey for students in grades 9-12. Educators, who met the eligibility requirements (see Educator Recruitment Process below) and had their students complete a student survey, were given a $50 stipend. Details of the educator recruitment process, the student surveys, and data analysis are provided in the following sections.

Educator Recruitment Process

A list of educators in Santa Clara County, who applied for and received support from the Foundation during the 2011-2012 academic year, was given to the evaluation team by Gary Robinson, CEO of the Foundation. This list had a total of 243 contacts, including 179 elementary school educators, 40 middle school educators, and 24 high school educators. Educator contact information included email addresses, phone numbers, the names of schools and districts that the contacts worked with, the number of students served, and the number of science fair projects that the Foundation supported.

In early April 2012, an email was sent from the WestEd STEM evaluation team to all 243 contacts informing them of the evaluation study and an invitation to participate in the project. These educators were informed that participation was voluntary, that their identity would not be associated with the student data, and that they would receive a $50 stipend for completing the project requirements. These requirements included completing an online educator intake survey, administering an online student survey during the month of May 2012, and emailing the evaluation team when their students had completed the online survey.

The purpose of the online educator intake survey was to recruit interested participants who served the targeted student population (i.e., grades 4-12) and to verify interested participants’ contact information. Additional purposes of the survey were to ascertain participant’s ability to administer the online student surveys during the month of May, ensure student access to computers, and confirm their student's ability to access the online survey site (i.e., Zoomerang). Interested participants were asked in the intake survey if their principal’s (or other administrator’s) permission was needed in order to administer the student survey. If permission was needed, principals were sent an email from the evaluation team with an attached letter from the Foundation outlining the purpose and scope of the study.

Additional educators were also identified during the recruitment process through these initial contacts. The additional educators included teachers who were given the support materials to use in their classroom, most often by the initial contact who served as the science coordinator for their school or district. Another 56 participants were recruited through this process. In total, 279
educators were approached by the evaluation team to participate in the project and sent invitations to take the educator intake survey. Of these potential participants, 94 completed the survey.

Eighty-six of the educators who completed the intake survey met the eligibility requirements (i.e., access to a classroom set of computers, ability to administer the student survey in the month of May, etc.). Interested and eligible educators were assigned a unique three-digit numerical identifier by the evaluation team for student use on the survey. All 86 participants were notified by email that they were eligible to administer the survey and to receive the $50 stipend. Participants were sent a notification in late April 2012 with links to the student surveys, directions on administering the survey, and their unique three-digit numerical identifier.

Participants only received links to student surveys for those grades they reported having the ability to administer (i.e., upper elementary, middle school and high school). Participants were given until the first week of June 2012 for their students to complete the surveys and to inform the evaluation team that they had completed the process. In total, 55 teachers completed the process and received the $50 stipend.

Student Surveys

Three online student surveys were developed for the purposes of the evaluation (i) an Upper Elementary Student Survey (for grades 4 & 5), (ii) a Middle School Student Survey (for grades 6-8) and (iii) a High School Student Survey (for grades 9-12). The three surveys included comparable content. Based on feedback from a WestEd associated reading specialist, the Upper Elementary and Middle School Student Survey items were analyzed and modified specifically for the high percentage of English Language Learners in the targeted student audience.

The High School and Middle School Student surveys had 44 questions, and the Upper Elementary Student Survey had 43 questions. Each survey had 3 open-response items and a variety of forced-choice items (e.g., yes/no, multiple choice, ratings, etc.). All questions were mandatory. Students were asked to provide their teacher’s 3-digit code; no personally identifying information was collected (i.e., no names, no student IDs, etc.). Through survey design, students who reported not completing a science fair project and/or did not participate in a science fair during the 2012 academic year did not complete all the survey items and their responses were not included in the data analysis or results.

Items on the student surveys were developed by the evaluation team, several were adapted from other science-related student surveys and all items vetted with the Foundation team to ensure face validity.

Methods of Analysis

A mixed methods design was used to address the evaluation questions. Quantitative data included a variety of forced-response items from surveys that included yes or no items, rating-scale items, and multiple-selection items. Qualitative data included open-response survey items.
A combination of grounded theory and established methods for coding qualitative data was used to identify and categorize factors that the students described regarding their experience with the Foundation funded science fair projects. All quantitative data were loaded into statistical analysis software (SPSS v.16) and analyzed using standard statistical analysis techniques. Paired t-test analyses were done on survey items where students were asked to rate themselves “Before” and “After.” Data were triangulated in order to assess students’ experiences and to make informed recommendations.
Results

Results contain demographics of students who completed the surveys and include: students gender and grade level, students science fair attendance, sources for students science project ideas, places students worked on their projects and the amount of time they spent working on these projects. Data on students’ team and collaboration experiences in the science fair projects were analyzed and included in the results. Changes in students’ perceptions of their project management, scientific investigation, scientific analysis, and communication skills are presented, as are their attitudes towards science as a result of participation in a science fair project. Students’ responses to the three open-response survey items were analyzed for major themes and included in the results.

Student Demographics

One thousand six hundred students in Santa Clara County, who worked on a science fair project and participated in a science fair in the 2011-2012 academic year, completed one of three online student surveys: (i) the Upper Elementary Survey for students in grades 4 and 5, (ii) the Middle School Student survey for students in grades 6-8, and (iii) the High School Student survey for students in grades 9-12. More 5th graders completed the survey (37%) than students in other grades, followed by 4th graders (20%), 6th graders (14%) and 8th graders (8%) (see Figure 1 and Table 1). A small percentage of 6th grade students (n = 9) completed the Upper Elementary Student Survey (see Table 1). More girls completed the surveys overall, 52% compared to 48% for the boys (see Figure 2).

![Image of bar chart showing frequency of students by grade level](image-url)

Figure 1: Frequency of students by grade level who completed a survey.

\[ n = 1600 \]
Table 1: Student demographics by grade level.

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Students</th>
<th>Girls/Boys</th>
<th>Grade Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Elementary</td>
<td>918</td>
<td>Girls = 486 (53%)</td>
<td>4th = 316 (34%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Boys = 430 (47%)</td>
<td>5th = 593 (65%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6th = 9 (1%)</td>
</tr>
<tr>
<td>Middle School</td>
<td>450</td>
<td>Girls = 226 (51%)</td>
<td>6th = 214 (48%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Boys = 219 (49%)</td>
<td>7th = 108 (24%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8th = 128 (28%)</td>
</tr>
<tr>
<td>High School</td>
<td>232</td>
<td>Girls = 124 (54%)</td>
<td>9th = 87 (38%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Boys = 107 (46%)</td>
<td>10th = 53 (23%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>11th = 58 (25%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12th = 33 (14%)</td>
</tr>
</tbody>
</table>

Figure 2: Gender of students who completed a survey.

Background Variables

Background variables of students who completed a survey included all science fairs they attended in the 2011-2012 academic year, the sources for their science fair project ideas, the time they spent on their science fair project activities, and the places where they worked on these projects.

Science Fair Projects and Science Fair Attendance

All students were asked if they attended a science fair during the 2011-12 academic year. Almost all of the upper elementary (97%) and all middle school students (100%) reported attending a school-based science fair at their school. A significant percentage of high school students (83%) reported attending sciencepalooza! followed by a school based science fair (16%) at their school.
Sciencepalooza! is a fair held specifically for students in grades 9 to 12 attending schools in the East Side Union School District. Over 85% of the high school survey respondents were from this district.

Fifteen percent of the high school students, 13% of the middle school students, and 2% of the upper elementary students reported attending the Synopsys Championship. A small percentage of students reported attending the California State Science Fair (2% of high school students, 2% of middle school students and 1% of upper elementary students). Forty-one percent of upper elementary students reported that this was their first science fair project. In comparison, 49% of the high schools students and 40% of the middle school students said they had completed 4 or more other science projects in school.

Sources for Science Fair Project Ideas
Most students reported coming up with their own idea for the science fair project (69% of upper elementary students, 65% of middle school students, and 59% of high school students) (see Table 2). A higher percentage of high school students, followed by middle school students, reported being given an idea for their science fair project by a teacher. Other reported sources for students’ ideas included: help from family (e.g., mom, dad, sister, cousin, etc.), friends and friends of their family, library books, the Internet, and from Science Buddies.

Table 2: Did you develop your own idea for your science project, or did your teacher provide you with a list of ideas or assign one?

<table>
<thead>
<tr>
<th></th>
<th>Upper Elementary (918 students)</th>
<th>Middle School (450 students)</th>
<th>High School (232 students)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developed my/our own idea</td>
<td>629 (69)%</td>
<td>291 (65)%</td>
<td>138 (59%)</td>
</tr>
<tr>
<td>Was given an idea or list by my teacher</td>
<td>121 (13)%</td>
<td>84 (19)%</td>
<td>66 (28%)</td>
</tr>
</tbody>
</table>

Time Spent on Science Fair Project Activities
Students were asked to estimate how much time they spend working on their presentation board and other project activities. High school students reported spending the most time working on their presentation board, 36% spent four or more hours, followed by middle school students, 33% spend four or more hours, and upper elementary students, 28% spend four or more hours (see Table 3). Similarly, high school students also reported spending more time on other project-related activities besides their presentation board such as thinking up ideas, designing the experiment, doing the experiment, 62% spend four or more hours, 57% of middle school students spent four or more hours, and 28% of upper elementary students spent four or more hours (see Table 3).
<table>
<thead>
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<th>Table 3: Approximately how much time did you spend working on the following?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Working on the Presentation Board</strong></td>
</tr>
<tr>
<td>less than 1 hour</td>
</tr>
<tr>
<td>1 to 4 hours</td>
</tr>
<tr>
<td>4 to 8 hours</td>
</tr>
<tr>
<td>8 or more hours</td>
</tr>
<tr>
<td><strong>Other work besides Presentation Board</strong> (e.g., thinking up ideas, designing the experiment, doing the experiment, etc.)</td>
</tr>
<tr>
<td>less than 1 hour</td>
</tr>
<tr>
<td>1 to 4 hours</td>
</tr>
<tr>
<td>4 to 8 hours</td>
</tr>
<tr>
<td>8 or more hours</td>
</tr>
</tbody>
</table>

**Places Students Worked on Projects**

Students reported doing most of this work at home (82% of upper elementary students, 76% of middle school students, and 58% of high school students) (see Table 4). High school students were somewhat more likely to work on their science fair projects at school during class time (16%) but much more likely to work on their project at school during other times (19%) than middle school (2%) and upper elementary students (7%). Other places that students reported working on their projects included a friend or partner’s house, a library, a park, and a university (for a few high school students).

<table>
<thead>
<tr>
<th>Table 4: Where did you do most of this work?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>At school during class time</strong></td>
</tr>
<tr>
<td>At school during class time</td>
</tr>
<tr>
<td>At school during other times such as afterschool</td>
</tr>
<tr>
<td>At home</td>
</tr>
<tr>
<td>At another place outside of school</td>
</tr>
</tbody>
</table>
Teamwork and Collaboration

Teamwork and collaboration include students’ team experiences and other collaborative experiences they had such as working with a mentor or family member on their science fair project.

Teamwork

High school students were more likely to have worked on a team for their science fair project (n = 158 or 68%) followed by middle school (n = 141 or 31%) and upper elementary students (n = 215 or 23%). Only students who reported working on a team for their science fair project (n = 514 or 32% of total respondents) were asked to rate their agreement with the following statements: (i) I worked with people who had skills I didn’t, (ii) As a team, we were able to get more work done, (iii) I learned new skills from my team, (iv) It took longer to get work done as a team, (v) People on my team came up with ideas I didn’t think of, (vi) I learned how to work with people who had different ideas, and (vii) I learned how to get work done with a team (see Table 5). Students strongly agreed with these statements in a fairly consistent pattern across the three grade level groups with the highest levels of agreement within the upper elementary group. Students reported the highest level of agreement in being able to get more work done as a team (65% of upper elementary, 41% of middle school, and 29% of high school students). The second highest level of agreement students reported was in learning how to get work done with a team (59% of upper elementary, 31% of middle school, and 25% of high school students). The lowest levels of agreement students reported were for having worked with people who had skills that they didn’t (20% of upper elementary, 13% of middle school, and 8% of high school students). See Table 5 below.

Table 5: Students who “Strongly Agreed” regarding their team experience.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Upper Elementary (215 students)</th>
<th>Middle School (141 students)</th>
<th>High School (158 students)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I worked with people who had skills I didn’t</td>
<td>43 (20%)</td>
<td>19 (13%)</td>
<td>13 (8%)</td>
</tr>
<tr>
<td>As a team, we were able to get more work done.</td>
<td>144 (65%)</td>
<td>58 (41%)</td>
<td>46 (29%)</td>
</tr>
<tr>
<td>I learned new skills from my team</td>
<td>98 (45%)</td>
<td>32 (23%)</td>
<td>23 (15%)</td>
</tr>
<tr>
<td>It took longer to get work done as a team</td>
<td>N/A</td>
<td>10 (7%)</td>
<td>8 (5%)</td>
</tr>
<tr>
<td>People on my team came up with ideas I didn’t think of</td>
<td>57 (26%)</td>
<td>29 (21%)</td>
<td>17 (11%)</td>
</tr>
<tr>
<td>I learned how to work with people who had different ideas</td>
<td>73 (33%)</td>
<td>33 (23%)</td>
<td>30 (19%)</td>
</tr>
<tr>
<td>I learned how to get work done with a team</td>
<td>130 (59%)</td>
<td>44 (31%)</td>
<td>39 (25%)</td>
</tr>
</tbody>
</table>
Collaboration

Students were asked in the survey who else they worked with besides their teammates or classroom teacher. A few survey items were focused on the types of mentors students worked with and their attitudes towards these mentors.

Upper elementary students were asked “Did you work with an adult besides your teacher on your science project?” Middle and high school students were asked “Did you work with an adult mentor on your science fair project?” Seventy-eight percent of the upper elementary students reported working with an adult besides their teacher, 35% of the high school students and 48% of middle school students reported working more specifically with a mentor. These adults included classroom volunteers, family members, and professionals (see Figure 3). While upper elementary students (78%) and middle school students (76%) most often reported working with a family member on their science project, a smaller percentage of high school students (39%) made these claims. High school students reported working with a classroom volunteer at a higher rate (31%) than middle school (10%) and upper elementary students (7%). High school students were also more likely to reported working with a professional (22%) than middle school (12%) and upper elementary (2%) students. See Figure 3 below.

Figure 3: Types of mentors students worked with.

Other mentors students reported working with included their friend’s parents, other teachers at their school, and family friends. Even for students who did not work with a mentor, many strongly agree that working with a mentor can be helpful (34% of all upper elementary students, 28% of middle school students, and 21% of all high school students).
Project Management

Evaluation of students’ project management skills included a survey item where students were asked to self-rate their abilities to manage a project and meet deadlines “Before” and “After” finishing their science fair project. Survey results indicate positive changes in students’ perceptions of their abilities across all three groups (see Figure 4). In the “Very good” category positive gains for high school students (n = 232) were 14%, for middle school students (n = 450) positive gains were 15%, and for upper elementary students (n = 918) positive gains were 21% (see Table 6). Upper elementary students reported the highest gains overall (i.e., in both the Good and Very good categories) followed by middle school and high school students. Across the three groups these gains were significant (p < 0.01).

Figure 4: Rate your ability BEFORE and AFTER finishing your science fair project to manage a project and meet deadlines.

Table 6: Changes in students’ abilities to manage a project and meet deadlines.

<table>
<thead>
<tr>
<th>Changes in Responses from Before to After</th>
<th>Upper Elementary</th>
<th>Middle School</th>
<th>High School</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Low</td>
<td>-38 (4%)</td>
<td>-24 (6%)</td>
<td>-12 (5%)</td>
</tr>
<tr>
<td>Low</td>
<td>-127 (13%)</td>
<td>-58 (13%)</td>
<td>-28 (12%)</td>
</tr>
<tr>
<td>Good</td>
<td>-27 (3%)</td>
<td>+12 (3%)</td>
<td>+6 (3%)</td>
</tr>
<tr>
<td>Very Good</td>
<td>+192 (21%)</td>
<td>+70 (15%)</td>
<td>+34 (14%)</td>
</tr>
</tbody>
</table>

Change in responses significant to 0.001 (p < 0.01)
Scientific Investigation

Scientific investigation skills included changes in students’ perceptions of their abilities to develop an idea for an experiment, to plan an experiment, and to conduct an experiment. Data regarding the types of research materials and other materials (e.g., chemicals, living things, Internet data, etc.) that the students used in their experiments was also collected and analyzed.

Scientific Investigation Skills

Evaluation of students’ investigation skills included survey items where the students were asked to self-rate their abilities “Before” and “After” finishing their science fair project. These survey items asked students to rate their ability: (i) to develop an idea for an experiment, (ii) to plan an experiment, and (iii) to conduct an experiment. Survey results indicate positive changes in students’ perceptions of their abilities (see Figures 5, 6 and 7). For high school students (n = 232), positive gains were in the range of 14% to 17% in the “Very good” category (see Table 7). For middle school students (n = 450), positive gains were in the range of 23% to 24% in the “Very good” category (see Table 8). For upper elementary students (n = 918), positive gains were in the range of 26% to 39% in the “Very good” category (see Table 9).

Gains were significant across the three groups (p < 0.01). Upper elementary students reported the highest gains overall (i.e., for both the “Good” and “Very Good” categories) followed by middle school and high school students. All three groups showed the highest gains in their ability to develop an idea for an experiment. High school students reported lower gains in their ability to plan an experiment relative to developing an idea for and conducting an experiment (see Table 7). For upper elementary and middle school students, gains in their ability to conduct an experiment were slightly lower than their ability to plan an experiment (see Tables 8 and 9).
Figure 5: High school students’ ratings of their scientific investigation skills BEFORE and AFTER finishing their science fair project.

Table 7: Changes in high school students’ scientific investigation abilities.

<table>
<thead>
<tr>
<th>Change in responses from Before to After</th>
<th>To develop an idea for an experiment*</th>
<th>To plan an experiment*</th>
<th>To conduct an experiment*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Low</td>
<td>-16 (7%)</td>
<td>-15 (6%)</td>
<td>-9 (4%)</td>
</tr>
<tr>
<td>Low</td>
<td>-55 (24%)</td>
<td>-53 (23%)</td>
<td>-38 (17%)</td>
</tr>
<tr>
<td>Good</td>
<td>+32 (13%)</td>
<td>+36 (15%)</td>
<td>+10 (4%)</td>
</tr>
<tr>
<td>Very Good</td>
<td>+39 (17%)</td>
<td>+32 (14%)</td>
<td>+37 (16%)</td>
</tr>
</tbody>
</table>

*Change in responses significant to 0.001 (p < 0.01)
Middle School Students

*Rate your ability Before and After finishing your science project*

**to develop an idea for an experiment**

**to plan an experiment**

**to conduct an experiment**

![Bar chart showing changes in middle school students' scientific investigation skills.](image)

Figure 6: Middle school students’ ratings of their scientific investigation skills BEFORE and AFTER finishing their science fair project.

### Table 8: Changes in middle school students’ scientific investigation abilities.

<table>
<thead>
<tr>
<th>Change in responses from Before to After</th>
<th>To develop an idea for an experiment*</th>
<th>To plan an experiment*</th>
<th>To conduct an experiment*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Very Low</strong></td>
<td>-19 (4%)</td>
<td>-25 (6%)</td>
<td>-22 (5%)</td>
</tr>
<tr>
<td><strong>Low</strong></td>
<td>-104 (23%)</td>
<td>-80 (17%)</td>
<td>-41 (9%)</td>
</tr>
<tr>
<td><strong>Good</strong></td>
<td>+15 (4%)</td>
<td>-3 (&lt; 1%)</td>
<td>-42 (9%)</td>
</tr>
<tr>
<td><strong>Very Good</strong></td>
<td>+108 (24%)</td>
<td>+108 (24%)</td>
<td>+105 (23%)</td>
</tr>
</tbody>
</table>

*Change in responses significant to 0.01 (p < 0.01)
Figure 7: Upper elementary students ratings of their scientific investigation skills BEFORE and AFTER finishing their science fair project.

Table 9: Changes in upper elementary students scientific abilities.

<table>
<thead>
<tr>
<th>Change in responses from Before to After</th>
<th>To develop an idea for an experiment*</th>
<th>To plan an experiment*</th>
<th>To conduct an experiment*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Low</td>
<td>-37 (4%)</td>
<td>-37 (4%)</td>
<td>-46 (5%)</td>
</tr>
<tr>
<td>Low</td>
<td>-169 (19%)</td>
<td>-170 (18%)</td>
<td>-139 (15%)</td>
</tr>
<tr>
<td>Good</td>
<td>-152 (17%)</td>
<td>-45 (5%)</td>
<td>-53 (6%)</td>
</tr>
<tr>
<td>Very Good</td>
<td>+358 (39%)</td>
<td>+252 (27%)</td>
<td>+238 (26%)</td>
</tr>
</tbody>
</table>

*Change in responses significant to 0.01 (p < 0.01)
Research Resources

Students were asked what types of research resources they used in their science fair projects. Students in all three groups most often reported using a home or other computer to search the Internet (67% of upper elementary students, 83% of middle school students and 75% of high school students) (see Table 10). A smaller percentage of students used their science textbook (17% of upper elementary students, 22% of middle school and high school students) or materials from the school library (10% of upper elementary students, 17% of middle school students, and 18% of high school students) (see Table 10).

Students reported using other resources in addition to those listed in Table 10. These resources included library books, books at home, books about science fairs, personal experiences (e.g., by testing things, by observing things), interviewing people (e.g., family friends, other teachers, a professor, a manufacturer), Science Buddies, and library databases.

Table 10: Did you use any of these to do research for your science project?

<table>
<thead>
<tr>
<th>Survey Questions</th>
<th>Upper Elementary (918 students)</th>
<th>Middle School (450 students)</th>
<th>High School (232 students)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Our science text book</td>
<td>154 (17%)</td>
<td>101 (22%)</td>
<td>52 (22%)</td>
</tr>
<tr>
<td>Magazines or other books</td>
<td>60 (7%)</td>
<td>111 (25%)</td>
<td>28 (12%)</td>
</tr>
<tr>
<td>Materials from our school library</td>
<td>92 (10%)</td>
<td>75 (17%)</td>
<td>18 (8%)</td>
</tr>
<tr>
<td>School computers to search the Internet</td>
<td>242 (26%)</td>
<td>195 (43%)</td>
<td>128 (55%)</td>
</tr>
<tr>
<td>Home or other computers to search the Internet</td>
<td>613 (67%)</td>
<td>372 (83%)</td>
<td>175 (75%)</td>
</tr>
<tr>
<td>Television shows or videos</td>
<td>60 (6%)</td>
<td>44 (10%)</td>
<td>14 (6%)</td>
</tr>
<tr>
<td>Other</td>
<td>165 (18%)</td>
<td>58 (13%)</td>
<td>15 (6%)</td>
</tr>
</tbody>
</table>

Materials Used

Students were asked to report materials that they used in their science fair projects. Students in all three groups showed similar use of materials with Internet data (e.g., images to use in their experiment) being the most common for 62% of upper elementary, 65% of middle school and 71% of the high school students (See Figure 8). Students in all three groups also used chemicals (e.g., mixing and dissolving salt and sugar in water), living things (e.g., plants, animals, and bacteria), electricity (e.g., batteries and light), rocks and minerals (e.g., identifying types) and computer programs (e.g., a computer program to count calories).
Scientific Analysis

Scientific analysis skills included changes in students’ perceptions of their abilities to keep a logbook (i.e., to methodically collect and record data), to analyze data, and to create a chart or graph. Data regarding the types of measurement tools that the students used in their experiments was also collected and analyzed.

Scientific Analysis Skills

Evaluation of students’ investigation skills included survey items where the students were asked to self-rate their abilities “Before” and “After” finishing their science fair project. These survey items asked students to rate their ability: (i) to keep a logbook, (ii) to analyze data, and (iii) to create a chart or graph. Survey results indicate positive changes in students’ perceptions of their abilities (see Figures 9, 10, and 11). For high school students (n = 232), positive gains were in the range of 8% to 17% in the “Very good” category (see Table 11). For middle school students (n = 450), positive gains were in the range of 17% to 23% in the “Very good” category (see Table 12). For upper elementary students (n = 918), positive gains were in the range of 15% to 22% in the “Very good” category (see Table 13).

Across the three groups these gains were significant (p < 0.01). Upper elementary students reported the highest gains overall (i.e., for both the “Good” and “Very Good” categories) followed by middle school and high school students. High school, middle school, and upper elementary groups showed the highest gains in their ability to keep a logbook (see Tables 11, 12, and 13).
Figure 9: High school students’ ratings of their scientific analysis skills BEFORE and AFTER finishing their science fair project.

Table 11: Changes in High School students’ scientific analysis skills.

<table>
<thead>
<tr>
<th>Change in responses from Before to After</th>
<th>To keep a log book</th>
<th>To analyze data</th>
<th>To create a chart or graph</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Low</td>
<td>-24 (11%)</td>
<td>-17 (7%)</td>
<td>-14 (6%)</td>
</tr>
<tr>
<td>Low</td>
<td>-59 (26%)</td>
<td>-42 (18%)</td>
<td>-34 (15%)</td>
</tr>
<tr>
<td>Good</td>
<td>+43 (18%)</td>
<td>+18 (8%)</td>
<td>+22 (9%)</td>
</tr>
<tr>
<td>Very Good</td>
<td>+20 (8%)</td>
<td>+41 (17%)</td>
<td>+26 (12%)</td>
</tr>
</tbody>
</table>

Change in responses significant to 0.01 (p < 0.01)
Figure 10: Middle school students’ ratings of their scientific analysis skills BEFORE and AFTER finishing their science fair project.

Table 12: Changes in Middle School students’ scientific analysis skills.

<table>
<thead>
<tr>
<th>Change in responses from Before to After</th>
<th>To keep a log book*</th>
<th>To analyze data*</th>
<th>To create a chart or graph*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Very Low</strong></td>
<td>-43 (9%)</td>
<td>-17 (4%)</td>
<td>-35 (8%)</td>
</tr>
<tr>
<td><strong>Low</strong></td>
<td>-65 (15%)</td>
<td>-85 (19%)</td>
<td>-68 (15%)</td>
</tr>
<tr>
<td><strong>Good</strong></td>
<td>+35 (8%)</td>
<td>+8 (2%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td><strong>Very Good</strong></td>
<td>+73 (17%)</td>
<td>+94 (21%)</td>
<td>+103 (23%)</td>
</tr>
</tbody>
</table>

Change in responses significant to 0.01 (p < 0.01)
Upper Elementary Students

Rate your ability Before and After finishing your science project

**Figure 11**: Upper elementary school students’ ratings of their scientific analysis skills BEFORE and AFTER finishing their science fair project.

<table>
<thead>
<tr>
<th>Change in responses from Before to After</th>
<th>To keep a log book</th>
<th>To create a chart or graph</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Very Low</strong></td>
<td>-81 (9%)</td>
<td>-61 (7%)</td>
</tr>
<tr>
<td><strong>Low</strong></td>
<td>-135 (14%)</td>
<td>-136 (15%)</td>
</tr>
<tr>
<td><strong>Good</strong></td>
<td>+73 (8%)</td>
<td>-4 (1%)</td>
</tr>
<tr>
<td><strong>Very Good</strong></td>
<td>+143 (15%)</td>
<td>+201 (22%)</td>
</tr>
</tbody>
</table>

*Change in responses significant to 0.01 (p < 0.01)

**Measurement Tools**

Students reported using a variety of basic measurement tools in their science fair projects. They were most likely to measure time (i.e., use of a stopwatch or timer) followed by distance (i.e., use of a ruler, yard stick, meter stick or tape measure) in their projects (see Figure 12). High school students were more likely to use these tools (53% used a timer or stopwatch and 58% used a ruler, yard stick, meter stick or tape measure) than middle school (43% and 50% respectively) or upper elementary students (26% and 34% respectively). A smaller percentage of students measured weight (i.e., weight scale or balance), temperature (i.e., thermometer), or pressure (i.e., barometer) with high school students leading in the usage of these basic measurement tools (see Figure 12).
Figure 12: Basic measurement tools used by students.

A smaller percentage of students overall, under 16%, reported using more advanced measurement tools such as a voltmeter and/or ammeter, a microscope or magnifying glass, pH paper or a pH meter, a lux meter, a kilowatt meter, and a uv meter. Usage of these tools was higher among the high school students and less common among the upper elementary students (see Figure 13).
Students reported using a variety of other measurement tools in their science project in addition to those mentioned in Figures 12 and 13. These measurement tools included measuring cups, a compass, a protractor, a blood pressure gauge, and an oscilloscope.

### Communication

Evaluation of students’ scientific communication skills included survey items where students were asked to self-rate of their abilities “Before” and “After” finishing their science fair project. These survey questions included the ability (i) to write results, (ii) to create a presentation board, and (iii) to discuss and present results to an adult besides my teacher. Survey results indicate positive changes in students’ perceptions of these abilities across all three groups (see Figures 14, 15 and 16). For high school students (n = 232), positive gains were in the range of 14% to 16% in the “Very good” category (see Table 14). For middle school students (n = 450), positive gains were in the range of 19% to 28% in the “Very good” category (see Table 15). For upper elementary students (n = 918), positive gains were in the range of 21% to 34% in the “Very good” category (see Table 16).

Across the three groups these gains were significant (p < 0.01). Upper elementary students reported the highest gains followed by middle school and high school. All three groups showed the highest gains in their ability to create a presentation board. High school and middle school students had lower gains in their ability write results relative to discussing and presenting results to an adult beside their teacher (see Tables 14 and 15). Upper elementary showed greater gains in their perceived ability to write results followed by the ability to discuss and present results to an adult besides their teacher (see Table 16).
High School Students

Rate your ability Before and After finishing your science project

Figure 14: High school students’ ratings of their communication skills BEFORE and AFTER finishing their science fair project.

Table 14: Changes in High School students’ scientific communication skills.

<table>
<thead>
<tr>
<th>Change in responses from Before to After</th>
<th>To write results*</th>
<th>To create a presentation board*</th>
<th>To discuss and present results*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Low</td>
<td>-8 (4%)</td>
<td>-10 (4%)</td>
<td>-13 (5%)</td>
</tr>
<tr>
<td>Low</td>
<td>-37 (16%)</td>
<td>-27 (12%)</td>
<td>-26 (11%)</td>
</tr>
<tr>
<td>Good</td>
<td>+12 (5%)</td>
<td>-5 (2%)</td>
<td>+1 (&lt; 1%)</td>
</tr>
<tr>
<td>Very Good</td>
<td>+33 (14%)</td>
<td>+42 (18%)</td>
<td>+38 (16%)</td>
</tr>
</tbody>
</table>

*Change in responses significant to 0.001 (p < 0.01)
Middle School Students

Rate your ability Before and After finishing your science project

<table>
<thead>
<tr>
<th></th>
<th>To write results</th>
<th>To create a presentation board</th>
<th>To discuss/present results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Very Low</strong></td>
<td>-17 (4%)</td>
<td>-23 (5%)</td>
<td>-33 (8%)</td>
</tr>
<tr>
<td><strong>Low</strong></td>
<td>-75 (17%)</td>
<td>-44 (9%)</td>
<td>-66 (15%)</td>
</tr>
<tr>
<td><strong>Good</strong></td>
<td>+7 (1%)</td>
<td>-60 (14%)</td>
<td>+8 (2%)</td>
</tr>
<tr>
<td><strong>Very Good</strong></td>
<td>+85 (19%)</td>
<td>+127 (28%)</td>
<td>+91 (21%)</td>
</tr>
</tbody>
</table>

*Change in responses significant to 0.01 (p < 0.01)
Figure 16: Upper elementary students’ ratings of their communication skills BEFORE and AFTER finishing their science fair project.

Table 16: Changes in upper elementary students’ scientific communication skills.

<table>
<thead>
<tr>
<th>Change in responses from Before to After</th>
<th>To write results*</th>
<th>To create a presentation board*</th>
<th>To discuss and present results*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Very Low</strong></td>
<td>-31 (3%)</td>
<td>-28 (3%)</td>
<td>-45 (5%)</td>
</tr>
<tr>
<td><strong>Low</strong></td>
<td>-137 (15%)</td>
<td>-117 (13%)</td>
<td>-130 (14%)</td>
</tr>
<tr>
<td><strong>Good</strong></td>
<td>-66 (8%)</td>
<td>-166 (18%)</td>
<td>-18 (2%)</td>
</tr>
<tr>
<td><strong>Very Good</strong></td>
<td>+234 (26%)</td>
<td>+311 (34%)</td>
<td>+193 (21%)</td>
</tr>
</tbody>
</table>

*Change in responses significant to 0.01 (p < 0.01)
Attitudes Towards Science

Evaluation of students’ attitudes towards science included two survey items where students were asked to rate their agreement with the following: (i) Doing a science project in school can help me do science on my own, and (ii) Doing a science project helped me better understand what scientists do. Upper elementary students reported the highest levels of agreement with over 80% agreeing (i.e., “Agree” and “Strongly Agree”) with both statements (see Figure 17 and 18). Middle school students were also in high agreement with both statements (over 70% reported “Agree” and “Strongly Agree”). These frequencies were somewhat lower for high school students, 69% “Agree” and “Strongly Agree” that doing a science project helped them to do science on their own and 72% “Agree” and “Strongly Agree” that doing a science project helped them to understand what scientists do (See Figures 17 and 18).

![Figure 17: Doing a science project in school can help me do science on my own.](image-url)
Open-ended Survey Items

Open-response survey items were developed to gather more descriptive data regarding the students’ experiences with the science fair projects. The open-response survey items included: (i) What were the best things about doing a science project?, (ii) What were the hardest things about doing a science fair project?, and, (iii) What surprised you about doing a science fair project? These responses were analyzed to determine common themes.

What Were the Best Things About Doing a Science Project?

Overall themes that emerged across students responses included: learning new things; having fun; working with others (e.g., friends, team, family, etc.); a sense of ownership (i.e., exploring own interests and passions, being able to pick project, etc.); presenting results (i.e., to others, to class, to judges, etc.); hands-on activities (e.g., building the project, doing the experiment, etc.); preparing the presentation board; attending the fair (recognition); getting points or improving grades; and developing skills (to use later in life, beneficial life skills).

High school students and some middle school students also reported the opportunity to work on or solve real problems that will have a benefit to society. Upper elementary students frequently mentioned working with family members.

Several students reported “nothing” or “didn’t know” others said “boring.”
Upper Elementary Students Responses

“I really loved doing my project, it was so much fun doing a science project because you get to learn something new, and you could learn from your mistakes and have so much fun !!!”

“The best thing is being able to learn new things. If you worked with a partner you’d be able to learn how to work with others. Experimenting the project is very interesting because somethings you don't expect or something weird happens.”

"You get to learn in a fun way, whatever you want to know more about. There aren’t really any rules about what you have to do it on. I liked that it was your idea."

“The best things were actually doing the science experiment and making the parachutes in my project.”

“The best thing about doing a science project was displaying it. My other favorite part was finding the outcome, and designing my graphs.”

“I get to be creative and I be responsible for doing the whole project myself. I learned to be organized and tidy to show my work.”

“We got to experiment with different objects and got to make a hypothesis. Although my hypothesis was incorrect, I still learned a lot about my topic. The judges were very nice and gave us positive feedback. In all, my favorite thing about my science project was presenting it to the judges.”

“Decorating the back board and showing people my science fair project. Decorating the backboard was fun because I got to be myself and cut and glue. Showing my project was fun because I was next to my friend and got to talk and present.”

"I worked with my friend and we got more things done faster. If I didn't work with a partner I would of gotten a really bad grade and there's nothing better than working with your best friend some people didn't finish their science fair project because they were just messing around THE END”

“I think the best part about doing a science fair project is when you do the experiment. The experiment is the best part because you will get the results and the results is exciting.”

“I can feel like a real scientist. Also, I like to do hands-on things to really understand what is happening, so I really enjoy and I think Science Fairs are very educational!”

"I got to have a lot of fun doing my project. I was chosen to be in the top ten. I was able to take a bow because I was in the top ten."
“First to see if my hypothesis was right, then to decorate my board, next to show it to the class.”

“The best thing was the actual experiments. It was also fun to have my older siblings giving me input on what to do if I was stuck.”

“I got to use sugar and mine was about rock candy and I like rocks. It was fun working with my mother.”

"My dad and I got to launch tons of rockets into the air it was so much fun."

"I got to use my mind. I got to be creative and myself. You get to learn things you didn't know.”

“I learned how to do a science project and it was cool. It was also fun to see the completed board! I loved seeing all the boards together.”

Middle School Students Responses

“Learning about the science project I did. Learning about other people’s science projects.”

“It helps you learn time management and I learned interesting facts.”

“We got to move around in the classroom instead of just sitting there all period. It was pretty fun!”

“The best thing about doing a science fair project was that you got to learn new things, it helped me with future class assignments, and it helped me show people about stuff that people never knew before.”

“I think the best thing was probably having fun while learning. I'm not much of a science person, yet I had fun and enjoyed it because I was doing it with a friend.”

“I think that some of the best things about doing a Science Project include developing better communication skills, since you have to explain the project to your judge. Doing a science fair also helps make new, scientific questions that could help improve our nation's science academies by having environmental-friendly cars, houses, etc.”

“The fact that we can change our way of thinking about science and our world. It was fascinating to see how well people try do something cool and interesting.”

“I really don't know, I guess it was fun to learn new things I didn't know before. Also I liked how we worked as a team even thought we had different ideas. I guess I can say it was fun!”

“The best thing about doing a science fair project is that you are able to research and learn subjects in a more advanced way and are able to learn about new things.”
"That you learn something new and gets you to think about life and what to do to improve this world. It also teaches you what things inside of it so your body can eat or drink health for your body. Then when you go to a store you can pick the best item for you. It is also fun."

“The best thing is being able to go to a place where other kids your age had interesting projects. It was awesome talking to the judges, it was probably my favorite part after seeing everyone's projects.”

“The best things about doing a science project is it gives me the chance to do different things by myself or as a group. It also gives me the chance to challenge myself with the materials my teacher taught me.”

“The best thing when doing a science fair project is at the end when you have finished your poster board. This is the best because it looks great and shows off all the work you have learned through the project.”

“When the judges interview you, I like sharing what I did in my project and I love it when they ask a difficult question. I also like doing the experiment.”

“The best things about doing a science fair project is that you get to learn more information about your topic and that you can win prizes if it's really good. It helps you learn more about your topic than other people who didn't do a science fair project. You get teacher support, too.”

“You have experience on things that you wouldn't do if you didn't have this science fair. It's worth the grade that we get, and it forms a habit on skills for science projects in order to do it in the future.”

“I liked learning how to work as a team. Even though we all had different views on things, we were still able to get the work done. I also liked the feeling of finishing the science project.”

“You get to do your only poster in sixth grade but I wish we could do more projects because they help us learn and are fun.”

“I think the best thing was finding answers to questions yourself, and doing it hands-on.”

High School Students Responses

“Science projects are invaluable experiences because they allow students like me to actually use their brains to answer questions they want answered. And to do this, they will have to consult teachers, textbooks, libraries, and other databases. It's like being a detective and it's fun because the entire project is yours-- not some homework assignment. Further, you don't know the answer. Even better, your textbook won't give it to you. There is nothing predictable about it and it's a completely new experience from sitting and learning in a classroom-- it's happening in real time, and the results are unpredictable.”
“That you get to do an experiment or analyze new things. Working with a partner is also a great thing because you can both have a lot of ideas together as I did with my partner. The work is actually easy when you work with others. And you can meet and work with new people.”

“We have the opportunity to learn more about the course of our project and how it affects things that happen in the world.”

“The best thing about doing a science fair project was that we were able to learn about a new subject in a more extensive perspective than we would have in class.”

“The best thing about doing a science project was widening my view on the field of science and going in-depth in finding out new things that apply to everyday life.”

“Being able to do independent research and work outside of the traditional academic setting.”

“The best thing about doing a science project is conducting an experiment that peaks your interest and helps you get a better understanding in something you may want to do in the future.”

“The best thing about doing a science project is learning new things as you research more and more on your project. For example, over the process of several science projects, I learned more about vacuum, centrifugal force, gravity, kinetic energy, and much more.”

**What Were the Hardest Things About Doing a Science Project?**

Overall themes that emerged across the students responses included: choosing a project or thinking up an idea; writing the report and typing the results; doing the research; data collection or measurements; data analysis and graphing; project management; time management or meeting deadlines; getting the materials or equipment needed; being patient for results; not winning; the challenge level or amount of work; keeping good notes and maintaining a logbook; all the work involved; and, issues with teamwork.

**Upper Elementary Students Responses**

“You have to be very patient. Also when you find out you were proved incorrect.”

“The patience it takes to complete the entire project, the mistakes and starting over.”

“Making the board and waiting overnight for my project.”

“Turning it in on time.”

“For me it's concentrating on the experiment and managing my time.”

“The hardest part about the science fair project was choosing the layout for the board and making it look presentable.”
“Researching and choosing a question to observe.”

“Science can be hard because sometimes you don’t know what your science project is going to be about.”

“Choosing a project that you are excited about, coming up with a name that matches the project.”

“I think the hardest thing to do is to get everything written down.”

“The research.”

“You have to gather lots and lots of information!”

“Sometimes you ask your parents something they don’t know and then you look it up and you can’t find it.”

“The hardest things were trying to put my data into a graph on the computer, but with a little help from my mom and dad, it was easy.”

“In my project you have to find all the average and that was very hard.”

“The hardest thing about doing a science project is is that you have to keep track of what you are doing.”

“One of the hardest things for me personally was planning the times when I would go to peoples houses to test their dogs.”

“The hardest thing about doing a science project is that you have to be responsible for so many things and have to plan many things out on your own. Other than that, it was pretty simple once I got everything planned.”

“The hard part about my project was to measure the right measures in the measuring cup.”

“The hardest thing was finding the materials for the experiment.”

“Not having a computer at home.”

“I thought the hardest thing was getting people to help me test so I could put it on my data.”

“The hardest thing about doing science projects is doing the experiment over and over to make sure you are doing it right.”

“The hardest thing about doing a science project is doing the project. My friend and I had a hard time experimenting with the plant.”

“The hardest thing about the science project is you have to do things that might be hard.”

“That sometimes when you have a really hard project it can be really hard to do.”

“That there was a lot of work to do.”
“The parts where you explain how you got the answer because it is hard to explain on paper.”

“The hardest thing about science fair projects is that you have to present and talk about your project.”

“It was hard to get me to figure out how to layout all my information and papers.”

“Being afraid of not doing things right.”

**Middle School Students Responses**

“Coming up with an idea that you can actually do, or finding time.”

“...that we might not win at the end.”

“...all the work (printing, collecting data, etc.)”

“The hardest thing was that I had to do a lot of research and it took a lot of time.”

“The hardest thing about doing the science fair was trying to find the data for my experiment and to put all my new data on my board in there correct place and order.

“Finding information about the subject before you start the experiment.”

“I guess the hardest thing to do in a science project is coming up with a question itself- something creative, and logical, while having access to all of the supplies there. Without a question, a science project cannot be completed, because there is no topic to be experimenting on.”

“The hardest thing about doing a science project is finding the right information and interpenetrating data (not really good at science).”

“All the work--it takes too long sometimes and even though you did the best you could, you don't get recognized like other people do who may or may not have spent less time and dedication on their projects.”

“The hardest thing is facing a difficulty and trying to persevere through it and find a solution. Sometimes you just can't find a solution on your own and you need help.”

“The hardest thing is following it through and making up for any mistakes, and writing and recording every little thing down.”

“I don't really know... Again. I think just learning to manage your time into a way where you learn not to procrastinate. Other than that, my project was quite simple. Otherwise, it would be waiting for my materials to arrive.”
“How you have to do it in a small amount of time and have due dates and deadlines.”

“The hardest thing was conducting the experiment properly so I could get accurate results.”

“Trying to get everything done by the deadline. Sometimes things don’t go exactly as planned, so what do you do then? You have to come up with a new way to finish your project fast. Without completely rushing and messing up your project.”

“The hardest thing about doing a science project is getting the materials and building it”

“The hardest things about doing a science project is that the data needs to be correct or else you did everything wrong.”

“You have to write a strong report for the judges to like what you have done”

“Dealing with hardships of finding the results and finalizing them.”

“The hardest things about the science project is the planning and decorating my board.”

“It takes a lot of research. I had to go to the library to do my research. It was hard to do the outline I had to do it in my class, you have to type everything or handwrite it. I had a project where I had to take pictures so I had to go to Walgreens to print them and it took a long time because there is a big line then go to another line to purchase it. But it was really fun to learn new things.”

“The hardest thing is doing a method, having it not work and not having a back up plan.”

“The hardest thing about doing science projects is doing the data charts and logging in the data.”

**High School Students Responses**

“The hardest thing was trying to control and organize all the variables.”

“Trying to get my partner to cooperate and have an interest in the project since it was their idea.”

“Learning to use unknown equipment.”

“Choosing the right people to work with if in a team. Otherwise, simply coming up with satisfactory ideas that are reasonable to test in a safe environment.”

“The hardest thing is to grasp the concepts; that is, what you are trying to achieve, to demonstrate, or to prove. Once you know what you need to do, getting there will be easier.”
“Coming up with a question and then trying to find a mentor to teach you. Learning is the fun part!”

“The hardest thing about doing science projects is choosing a topic to work with.”

“The hardest thing about doing a science project was to come up with the procedures and all that stuff. Well actually first to come up with an experiment”

“The hardest thing to do was record date, because we often forgot to record it in the heat of the moment and would have to repeat trials. Also, if we wrote it on paper, we would sometimes misplace it.”

“Gathering information from the teammates is a hard task b/c it is crucial step to understand the procedure and the experiment.”

“The hardest thing about doing a science project would be developing the hypothesis and analyzing the data. There are many things to consider. The project must be conducted carefully.”

“The hardest thing about science projects is the experiment. Sometimes you have to do the same experiment multiple times.”

“The hardest thing about doing a science fair project is waiting for the data to collect and being clean about all your information. It’s also hard to be patient when you conduct the test more then once.”

“By being involved in a science project you take on the responsibility of having it done when entering a science fair. This means you have to devote your time in conducting your experiment and analyzing your results if you want to be as accurate as possible. The hardest thing about doing the science project is taking on the project is analyzing your results as it requires a lot of time.”

What Surprised You About Doing Your Science Project?
Overall themes that emerged across the students responses included: (i) surprising results (i.e., my hypothesis was right, it worked, it didn’t turn out the way I expected, the experiment failed, etc.); (ii) the project was harder than expected; (iii) using knowledge or learning from a class and applying it; (iv) amount of time it required; (v) how much fun it was; (vi) self-satisfaction in ability to conduct and complete the project or do better than expected; (vii) judges; and (viii) ability to work well as a team.

Upper Elementary Students Responses

“I was surprised when the ice floated in the oil because I thought olive oil would be denser than ice. I was surprised when the ice floated in canola oil also!”

“I got a better score than I expected and I did such a neater job than last year and I put more information in to my science project!”
“I was surprised on how fun this project was. I used to think it would be a very boring thing to do. I want to do this again sometime!”

“That I could actually make a complicated graph with only a little bit of help from my parent. That science fair projects aren’t that boring.”

“How the objects showed up on the sun print paper. :)

“I was a little surprised at how my board turned out. At first, I thought it would be okay as far as looks, but it turned out looking great!!!!!”

“Well my prediction was completely wrong. I was very surprised because my hypothesis seemed reasonable”

“Before, I was a little surprised because I didn’t know that my hypothesis was wrong. But I can explain it.”

“It was easier then I thought. It was pretty fun! It felt good to do a project on my own and get to display it for people to see.”

“My hypothesis was partially correct. And my board didn’t turn out how I expected it would.”

“While I was waiting till the leaf changed color the oak tree leaf first was red then turned green. What also surprised me is that a special kind of paper, nail polish remover, and leaves you could change color of a leaf.”

“I was surprised by how long it took”

“I did the whole thing myself and I remembered what i had to do every night.

“I thought it would be hard since it was my first time, but it was a nice learning experience and fun.

“It surprised me because of how much I learned. I thought this was going to be a simple science project. It was easy but at the end I learned a load of things

“Things that surprised me were that my results were kind of weird. I also thought that doing a science fair project would be hard, but it was actually easy.”

"How it surprised was when our teacher said we have to do one, and when i couldn't find a partner but I did. It was so fun a little because my partner didn't want to work and I mostly did all of it, she did nothing"

“What surprised me was that last year I did not do very good and this year it was way better. Another thing that surprised me was that during my science project I noticed new things that I never knew before.”

“I was surprised about how much time it took to gather info, hypothesize, and make a board! I also was shocked on how the experiment followed my hypothesis.”
“Something that surprised me during the process of the end of my project was that I thought the right brain controlled the right side of your body and your left brain controlled your left side.”

“I wasn’t that surprised because I thought it was going to be hard and plus it was going to be my first time in 4th grade. But now in 5th grade I got used to it because I got more confidence in myself. Since now I’m going into 6th grade I will try to win.”

“Talking with the judges.”

Middle School Students Responses

“That there are many variables that sometimes you don’t think of (in my case, people who had glasses and people who did not).”

“How results can come out completely different than expected.”

“What surprised me about doing my science project was the difficulty of time management; the way that the science project time had passed in our class was quite sloppy, for the teacher had only given us a month to do all of it, and some people hadn’t had a question at the time. Aside from the time management, there really was nothing else to be surprised about.”

“How fun it would be. I thought all projects would be boring and so unusual to think of, but in fact it was the complete opposite.”

“It was easier than I thought it was going to be though it did stress me out finding all the info and putting the presentation board with my partner.”

“The deadlines were very close. The amount of time we had to finish each part was too small but I still finished on time.”

“My increased knowledge and ability to perform forensic experiments.”

"That I can’t believe I finish in time and I wasn’t very nervous this time as last year. I knew I was going to do great. I used new things I didn’t know about.”

“The things that surprised me about doing my science project was how long it actually took. Another thing was how much I really learned.”

“I don’t really know. I think that because I have done a similar project in the past, how the results can change so dramatically when making your project the least bit more scientific.”

“I was surprised that San Tomas, 1.5 miles from the freeway, was the busiest road.”

“How difficult it was to actually get a lux meter. I had to go to my grandparent’s house to do the experiment because they had a lux meter.”
“How much work I had to do because I picked plants as a topic.”
“The judges expected too much from a 7th grader and my project looked well but the again the judges expected too much”
“It took really long and I never worked so hard in my life before. I learned new things doing the research and my knowledge about vitamin c increased.”
“You may learn many things through one project. It helps your education in developing a stronger intellectual understanding of the scientific subject with the project.”
“I found out a lot more about the properties of electricity, and I was surprised about some of the information I learned when I was doing research before conducting my experiment.”
“The thing that surprised me about doing my science project was that my hypothesis was correct, even though I wasn't very sure about it being correct.”

High School Students Responses

“The new things we learned about our experiment surprised me the most.”
“I couldn't just have a vague idea about my project. Even though I thought I could do many things with my potential research topic, actually planning the steps to form the procedure was much more difficult than I thought.”
“I could actually carry out doing a science fair project and explain my results. I found that my results could potentially be helpful too!”
“The science project was different than I had expected. I thought it would mostly be work, but it turned out that mastering the concepts was everything. Once I got the concepts, the rest was relatively easy.”
“I was surprised my partner and I were able to smoothly complete the project (it being our first time) and just making it to the synopsis fair.”
“How easy it is to desperately want to quit during the science fair process.”
“The speed at which my results were able to materialize.”
“What surprised me during my science project is that people usually say what they see first. For example if there is a triangle but it says square inside the triangle the first thing the person sees is the word square rather than saying the shape which is a triangle.”
“What surprised me about my project was that my hypothesis was very accurate, I did not expect it to me so accurate.”
“I expected the project to be very short and easy to do, but I was very wrong. It was time consuming building, testing, and organizing everything and with many schedule complications, I was surprised we had enough time.”

“I was able to take knowledge of analyzing from my AP Statistics class and was able to use it in my project.”

“We were right and won with a project we didn’t think was a good idea but worked in the end”

“How insightful it was yet a fun experience”

“What I was surprised about doing my science project is that my science project actually got an award at Sciencepalooza!”

"Dodder is not allowed to be grown for experimental purposes in the U.S. And also some plants are resistant to dodder’s effects.”

“What surprised me most about doing the science fair project was how easy it is if you manage your time wisely and turn everything in. If you divide up the work with your partner, then things are easier to finish and you become less flustered with all the work.”

“The amount of information I learned about temperature, formic acid, and corrosion (which were three variables in my project).”

“I was surprised by the reality of doing an engineering project, and that things do not always go as planned.”

Discussion

Results of the student surveys are encouraging on many levels. It is clear that students in grades 4 through 12 who participated in the Synopsys Outreach Foundation funded science fair projects in 2011-2012 showed overall high levels of engagement and value in their science fair projects. Students reported significant gains (p < 0.01) in several important categories including their abilities to: manage a project and meet deadlines; develop an idea for an experiment, plan an experiment, and conduct an experiment; keep a logbook, analyze data, and create a chart or graph; and report results, to create a presentation board, to discuss and present results to an adult other than their teacher. These findings are important in that they highlight the potential of the project-based science fair activities in improving student learning in science.

Survey instruments were specifically developed for this study to capture student outcomes and 21st century skills associated with the Synopsys Outreach Foundation (SOF) funded science fair projects in 2011-12. Assessment of students’ 21st century skills is a relatively new phenomenon lacking a set of valid and reliable instruments in the area of K-12 science education. The student survey instruments developed for this study were unique in these regards and provide a means of understanding students’ experiences in the SOF funded science fair projects, particularly through
the lens of important 21st century learning skills that include critical thinking, communication and collaboration.

Data collection was limited to students’ self-reported post perceptions of their experiences and did not include quantitative measures of students’ knowledge or skills. The study findings are meaningful in that they reflect other critical measures of learning such as student motivation, interest, and levels of engagement. These results are even more consequential when contextualized within the state of K-12 science education in California.

Synopsys Outreach Foundation provides valuable services to teachers and their students in Santa Clara County by providing materials, support and in sponsoring science fairs. Given the dramatic decline in funding for science education in California over the past 10 years, these services are critically needed by schools serving students from lower socio-economic communities, including many in Santa Clara County.

Recent studies conducted by the Center for the Future of Teaching and Learning at WestEd in collaboration with The Lawrence Hall of Science at the University of California, Berkeley and SRI International provide a snapshot of the state K-8 science education in California and a context to better appreciate the findings of this study. Through extensive surveys of district administrators, middle school principals and middle school teachers statewide, Dorph et al. (2011) found that only 10% of California public elementary school students regularly experience high-quality science learning.

Forty percent of elementary teachers in grades K-5 who participated one study, High Hopes – Few Opportunities: The Status of Elementary Science Education in California, reported that their students receive 60 minutes or less of science instruction per week. Only one-third of elementary teachers in the study reported that they felt very prepared to teach science where opportunities for professional development are scarce; 80% of the teachers statewide have not received any science-related professional development in the last 3 years. Assessment of student learning in elementary science is also problematic. The only statewide elementary science assessment, given in 5th grade, does not capture all of the important learning outcomes related to science. Furthermore, 66% of elementary teachers reported that they receive little or no support in assessing their students’ learning in science. And a substantial percentage of elementary school teachers statewide reported that “rarely” or “never” had their students design their own investigations (63%), had their students do fieldwork (79%), had students write reports (64%), had their students present to the class (53%), or had their students listen and take notes (34%). (Dorph et al., 2011)

It is not a stretch to claim that too many students enter middle school in California unprepared to engage in the science instruction they encounter. This reality is compounded by national research that has shown a dramatic decline in interest in science as students transition into middle school and that trend persists into college, graduate school and careers (National Research Council, 2012). Hartry et al. (2012) in their study of middle school science education, Untapped Potential: The Status of Middle School Science Education in California, estimate that only 14% of teachers in their statewide sample used a pattern of classroom practices that supported regular engagement in the practices of science that includes students working in groups, doing hands-on
science activities, designing their own investigations, participating in field work, recording, representing, or analyzing data, writing reflections or presenting to the class. In contrast to outcomes from the earlier elementary study, many of the middle school teachers surveyed claimed that their students were uninterested or unengaged in learning science. Even more alarming, only 20% of California students were proficient on the 8th grade National Assessment of Educational Progress (NAEP) science exam in 2009.

As highlighted through these studies, the SOF funded science fair projects are meeting a significant need in science education by providing the materials and support to teachers in order to engage their students in hands-on scientific investigations. The evaluation findings are encouraging in that the students had overall high levels of satisfaction with their science fair project experiences. Students communicated a sense of ownership in their work and were engaged in the recommended practices of science that are uniformly neglected in too many of California’s science classrooms including doing hands-on activities, designing their own investigations, participating in field work, recording, representing, and analyzing data, writing reflections and presenting their findings. Through these science fair projects, students also collaborated with a variety of mentors including family members and conducted scientific research outside of class time. Even more importantly, most students experienced a sense of excitement and appreciation for their scientific investigation process.

A substantial majority of students in all three grade-level groups, upper elementary (4th and 5th grade), middle school (6th, 7th, and 8th grade), and high school (9th, 10th, 11th, and 12th grade) reported spending four or more hours working on their science fair projects and carrying out much of this work outside of their science class time. The science fair projects offered many students an opportunity to explore topics of interest and conduct hands-on scientific investigations that often led to surprising results. In fact, the expressions “fun” and “learning” were reported throughout the open-response survey item, “What was the best thing about doing a science fair project?” Students overall reported having a sense of ownership and pride in their projects as one high school student eloquently states:

“Science projects are invaluable experiences because they allow students like me to actually use their brains to answer questions they want answered. And to do this, they will have to consult teachers, textbooks, libraries, and other databases. It’s like being a detective and it’s fun because the entire project is yours— not some homework assignment. Further, you don’t know the answer. Even better, your textbook won’t give it to you. There is nothing predictable about it and it’s a completely new experience from sitting and learning in a classroom— it’s happening in real time, and the results are unpredictable.”

The role of teamwork and collaboration were important components of the science fair project experience. While younger students, particularly upper elementary and middle school, were most likely to report working with a family member on their projects, all three grade level groups overwhelmingly reported working with others as an important component of the science fair project experience. As one middle school student simply states:

“I think the best thing was probably having fun while learning. I’m not much of a science person, yet I had fun and enjoyed it because I was doing it with a friend.”
The SOF funded science fair projects offered opportunities for students to use a variety of measurement tools from rulers to lux meters and explore research resources outside of their science textbook. Overall students reported positive gains in their understanding of what scientists do and in their ability to do science on their own.

Elementary students showed the highest levels of self-reported gains in skills and overall satisfaction with the science fair projects followed by middle and high school students. These trends are consistent with national studies that show a drop in students’ sense of self-efficacy and interest in science. Overview of the survey results offer insights into opportunities for growth and impact of the Synopsys Outreach Foundation funded science fair projects.

Recommendations are to:

- Provide continued support for the science fair projects and seek ways to provide additional guidance to teachers, parents and students in order to develop ideas for projects, to circulate research resources, and to communicate other useful information that can improve the students’ science fair project experience.

- Expand student access to advanced scientific measurement tools and provide support for using these tools.

- Find ways to recognize the important role that the students’ families and other mentors had in their science fair project.

Qualifications of Evaluator

WestEd is a preeminent educational research, development, and service organization with 600 employees and 16 offices nationwide. WestEd has been a leader in moving research into practice by conducting research and development (R&D) programs, projects, and evaluations; by providing training and technical assistance; and by working with policymakers and practitioners at state and local levels to carry out large-scale school improvement and innovative change efforts. In developing and applying the best available resources toward these goals, WestEd has built solid working relationships with education and community organizations at all levels, playing key roles in facilitating the efforts of others and in initiating important new improvement ventures. Over the past 43 years, WestEd and its two predecessors, Far West Laboratory for Educational Research and Development (FWL) and Southwest Regional Laboratory (SWRL), have carried out over 2,000 successful projects representing major contributions to the nation’s R&D resources. WestEd has a stable funding base and organizational structure for carrying out the work proposed for this evaluation of LEAD Computer Science Institute.
Personnel

Jennifer Mullin, Ph.D. is a Research Associate at WestEd with a doctorate in Engineering Education from Virginia Tech. Through her dissertation research, Dr. Mullin investigated student creativity in a cornerstone engineering design project. This research built on her work teaching and developing an innovative hands-on curriculum for a first year engineering course. Her interest in working with a younger and more diverse student population led her to teach engineering at a project-based charter high school. She is currently working with a research team developing 21st century skills assessments for middle school students. Dr. Mullin has served as an evaluator for a variety of middle and high school programs including Google CAPE, a summer computer science camp for middle school students, LEAD CSI, a residential university computer science program for middle and high school minority students and SHIP, a faculty mentored STEM research program for talented high school students at Sonoma State University.

Steve Schneider, Ph.D. is the Senior Program Director of Science, Technology, Engineering and Mathematics (STEM) at WestEd. Dr. Schneider has been the Principal Investigator of numerous initiatives that include: formative and summative evaluations of PBS Ready to Teach and Ready to Learn grants; the $10 million IES National Center for Cognition and Math Instruction, $12.2 million NSF Center for Assessment and Evaluation of Student Learning (CAESL); the NAEP Technology and Engineering Literacy Framework and the NAEP Science Framework and Test Specification projects; the What Works Clearinghouse Science Curriculum submissions; development of the National Board for Professional Teaching Standards Science Teacher Assessment; and the WestEd Eisenhower Mathematics and Science Regional Consortium. He has over 35 years of science, mathematics, and technology education experience, including K-12 pre-service teacher education, high school science teaching in biology, physics and oceanography, and professional development. He has published numerous articles on science, mathematics and technology education, professional development, and teacher preparation. He received his doctorate from Stanford University in the Design and Evaluation of Educational Programs with an emphasis in Science, Mathematics, and Technology Education, and a holds a bachelor’s degree in Biology from the University of California, Berkeley.

Mark Loveland, Ph.D. is a Senior Research Associate in the Science, Technology, Engineering, and Mathematics (STEM) program at WestEd. He is the director for WestEd’s project to design and develop a searchable database of effective STEM learning programs for Change the Equation. Dr. Loveland also serves as co-principal investigator on the IES funded SimScientists Interactive Simulation-Based Science Learning Environments and the SimScientists Assessment System project. Dr. Loveland has over 18 years of experience working in scientific research and science, mathematics, and technology education. Dr. Loveland’s experience in science education spans a wide spectrum, from teaching secondary biology, chemistry and environmental science to the development of formal and informal science education resources. He received his doctorate from Georgetown University in the Tumor Biology Program at the Lombardi Cancer Center and a bachelor’s degree in Biology from UCLA.
References


