Golden LEAF STEM Initiative Evaluation

Descriptive Data Report

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August 2012
This project received support from The Golden LEAF Foundation.

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GOLDEN LEAF STEM INITIATIVE EVALUATION DESCRIPTIVE DATA REPORT

Executive Summary

Student success in the core content areas of science, technology, engineering, and mathematics (STEM) is essential for the development of an American workforce that can compete in the global economy. In response to this critical need states across the country, including North Carolina, have developed K-12 initiatives designed to inspire and prepare the next generation of scientists, technicians, mathematicians, and engineers. In North Carolina, the Golden LEAF Foundation (Golden LEAF) is a leader in the effort to promote and sustain high quality STEM education in public schools. The Golden LEAF grants program provides strategic funding for innovative K-12 education projects. In 2010 the Foundation launched a STEM Initiative to support “successful models that increase STEM education for students in grades four through nine in rural, economically distressed, and/or tobacco-dependent counties of North Carolina.”

The Golden LEAF STEM Initiative evaluation team has been charged with both completing formative and summative evaluations and acting as a resource for the grantees who will be conducting some evaluation of their own. The two primary objectives of the Golden LEAF STEM Initiative evaluation are to:

- Provide information about the initiative’s implementation and the extent to which it achieved its stated goals, and
- Provide resources and support to increase the capacity of participating school and district staff to conduct their own program evaluation.

This report is the second in a series of two, baseline data reports for the Golden LEAF STEM Initiative evaluation. It is divided into the following five sections and a series of appendices.

I. Data and Analysis
II. Findings
III. Capacity-Building Activities
IV. Recommendations
V. Next Steps

The appendices contain descriptions of the grants, surveys, survey results, focus group protocols, an implementation rubric and its results, and capacity-building artifacts.

The Golden LEAF STEM Initiative

A special program of the Golden LEAF Board of Directors, the STEM Initiative targets projects that:


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- Are evidence-based and represent systemic approaches to STEM education, including in-school, out-of-school, or extended day and support programs providing assistance to students transitioning from elementary to middle and middle to high school.
- Represent collaborations among public schools and higher education, community, and relevant industry partners.
- Target improved preparation for and academic performance in advanced STEM curricula by minorities, females, and students from limited-resource families.
- Serve students in 4th through 9th grades, placing priority on curricular approaches that are integrated, use project- and inquiry-based learning concepts, and/or prepare students for successful completion of Algebra I by 8th or 9th grade – a gateway to participation in advanced placement courses.
- Include strategies that are comprehensive, incorporate content specific professional development for teachers, and provide relevant career and work connections for teachers and students.

In the spring of 2011 the board made awards totaling $5 million to 14 grantees. These three-year projects received varying amounts, the smallest grant was $100,000 to support a single-district project and the largest award was $600,000 to aid a regional collaboration. In total, these grants impact 225 schools, roughly 1,190 teachers, and approximately 31,890 students in 43 public school districts in North Carolina.

The Golden LEAF STEM Initiative Evaluation

The evaluation of the Golden LEAF STEM Initiative will take place over the three-year grant implementation period, 2011 through 2014.

Evaluation Objective 1:

The first objective of the evaluation is to describe the overall effectiveness of the Golden LEAF STEM Initiative in achieving its goal of improving STEM education outcomes for 4th through 9th graders in rural North Carolina. For this purpose quantitative and qualitative data is being collected from multiple sources in three separate time periods: September 2011 through April 2012 (completed), September 2012 through April 2013, and September 2013 through February 2014. The results from these three periods of data collection are synthesized and compared annually, assessing ongoing impacts.

Data sources described and analyzed in this report include: site visits, focus groups with participating teachers, classroom visits, teacher surveys, student surveys, and a STEM program implementation rubric. This information was collected in order to answer four, primary evaluation questions:

To what degree or in what ways were the Golden LEAF STEM Initiative grantees as a whole:

1. Faithful in implementing their STEM program’s criteria and goals?
2. Effective in changing student STEM attitudes?
3. Effective in changing student STEM learning?
4. Effective in changing teachers’ instructional practices?

Evaluation Objective 2:

The second objective of the Golden LEAF STEM Initiative evaluation is to provide resources and support to the grantees as they work to continually improve their individual programs. The evaluation team assists each of the grantees to:

- Develop and apply knowledge about education program evaluation; and
- Collect, interpret, and use formative data to improve their STEM programs.

Over the course of the three-year initiative various capacity-building events and activities take place: annual evaluation institutes, semi-annual webinars, the ongoing provision of formative data, access to online surveys, and access to one-on-one technical assistance from members of the evaluation team.

The first baseline report was completed in April 2012 and contained results from some of the data collected during the first report period, September 2011 through February of 2012. This descriptive data report extends that earlier work. It is designed to address evaluation questions 2-4 by summarizing results from surveys administered to over 600 teachers and approximately 10,000 students and site visits conducted at participating schools. Additionally, the report describes the evaluation capacity-building efforts that have taken place since February 2012.

Evaluation Results

To what degree or in what ways were the Golden LEAF STEM Initiative grantees as a whole effective in changing student attitudes toward STEM education?

Results from focus groups and classroom visits show that student engagement in STEM content was very high as a result of the hands-on, problem-based learning opportunities provided through the Golden LEAF STEM Initiative. Teachers participating in the focus groups reported that the hands-on activities specifically engaged students with a variety of learning styles, including visual and mechanically-inclined learners. Teachers noted that the collaborative, problem-based activities especially engaged female students. Survey data indicate that students overall have moderate levels of confidence in STEM subjects and generally mild interest in STEM careers. On average 40.5% of students, across 12 career areas, indicated that they were “interested” or “very interested” in a STEM-related field. Female students had particularly low levels of interest in engineering, computer science, energy, and physics as compared to male students.

To what degree or in what ways were the Golden LEAF STEM Initiative grantees as a whole effective in changing student learning in STEM?

Even though standardized tests may not detect any changes in student learning after a year of implementation, findings from focus group conversations suggest that teachers were finding that there had been an increase in student learning by other measures. Teachers observed students
themselves integrating content more frequently. Also the hands-on, problem-based STEM activities and curricula provided through the Golden LEAF STEM Initiative involved significant levels of group work among students — many teachers reported improvements in student communication and collaboration by the end of the school year. Correlating with this particular finding, student survey results indicated that students had the most confidence in their 21st century skills which include collaboration skills. Teachers also indicated that student’ problem-solving skills increased as a result of the curricular materials, activities, and other student-learning experiences provided by the Golden LEAF STEM Initiative.

To what degree or in what ways were the Golden LEAF STEM Initiative grantees as a whole effective in changing teachers’ instructional practice?

There is a lot of national-level discussion about the specific definition of the term “STEM education.” The teachers participating in the Golden LEAF STEM Initiative shared a common conception of its broad meaning. They repeatedly described STEM education as education that: focuses on integrating science, technology, engineering, and math concepts; teaches problem-solving skills; and prepares students for the unknown jobs of the future. Focus group results indicate that through their participation in the Golden LEAF STEM Initiative many of these STEM teachers improved their instructional practices. The educators reported that they had begun to teach with inquiry-based lessons and to integrate content across multiple subjects more frequently. By contrast, more mixed results on instructional outcomes came from the teacher surveys. Findings from the teacher surveys show that, overall, when asked about aspects of their instructional practice educators participating in the Golden LEAF STEM Initiative had a moderately strong sense of confidence and self-efficacy overall (3.9 scale-level mean composite score). Results also show, however, that the teachers had only mildly positive expectations that, in general, teachers’ efforts in classrooms significantly impact student achievement (3.4 scale-level mean composite score).

Reflecting on working conditions related to STEM programs, the participating teachers indicated that they benefited from the professional development they received. The educators reported that in the future they would benefit from more professional development that provides specific instructional resources and continuing education opportunities. Other working conditions were mentioned as well. The participating STEM teachers were clear that, in general, the lack of technology to support STEM instruction, lack of time in school schedules for STEM subjects, and the lack of opportunities for collaboration with other teachers all acted as barriers to their ability to provide even more effective instruction in STEM.

**Capacity-Building Activities**

The second objective of the Golden LEAF STEM Initiative evaluation is to provide technical assistance to increase the capacity of schools and districts for data-informed decision-making. In order to accomplish this goal the evaluation team has undertaken several activities thus far including: hosting annual face-to-face summer institutes, holding semi-annual webinars, maintaining a Golden LEAF STEM Initiative evaluation wiki, providing access to online student surveys.

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2 Survey responses were recorded on a five-point Likert scale: “strongly disagree” (1), “disagree” (2), “neither agree nor disagree” (3), “agree” (4), and “strongly agree” (5).
and teacher attitude surveys towards STEM education, providing survey results, developing a STEM program implementation rubric, and providing on-going access to evaluation team members as an implementation resource.

**Recommendations**

The data collected for this report demonstrate that the Golden LEAF STEM Initiative has produced successful overall results during the first year. The initiative, consisting of the individual work of the 14 grants from across North Carolina, has made progress toward achieving its goals. Findings suggest that as a result of initiative activities student engagement, student learning, and the knowledge and skills of participating STEM teachers have increased. With two years remaining for project implementation, the initiative has potential to produce more positive results and accomplishments in the future. Findings from the data collected for this report point to some activities which the grantees should continue to prioritize and others which grantees might consider adding to their implementation plans:

- Continue to implement hands-on, problem-based STEM curricula and activities; increase emphasis on rigor.
- Continue to raise student awareness of STEM careers and increase the frequency of opportunities for students to engage with STEM industries – especially through intentional strategies that further relationships between schools and industry (education and work).
- Continue to support female students through project-based or hands-on learning experiences to improve attitudes toward STEM subjects and careers.
- Increase collaborative time and/or peer-to-peer learning opportunities among teachers that are dedicated to supporting the integration of STEM content.
- Continue emphasizing the importance of creating meaningful opportunities for students to work in small groups.
- Increase the frequency of professional development opportunities that: provide resources, promote individualized learning goals, are content-specific, join teachers and industry professionals, and integrate subject areas.
- Provide more opportunities for meaningful collaboration among teachers in STEM subjects and across all subjects.
- Continue to seek out ways to prioritize and fund technology as instructional tools in STEM subjects.
- Seek out and promote scheduling solutions that provide more total time for students to learn STEM subjects and more flexible time for STEM activities that do not fit into regular school schedules.

The evaluation is being conducted by the Consortium for Educational Research and Evaluation– North Carolina (CERE–NC), a partnership of the SERVE Center at the University of North Carolina at Greensboro, the Carolina Institute for Public Policy at the University of North
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Carolina at Chapel Hill, and the Friday Institute for Educational Innovation at North Carolina State University. CERE–NC looks forward to continuing its investigation of the impacts of Golden LEAF-supported initiatives on STEM outcomes in North Carolina schools.
Introduction

The Golden LEAF Foundation STEM Initiative

The Golden LEAF Foundation (Golden LEAF) STEM Initiative, launched in 2010, supports successful education models that increase science, technology, engineering, and math (STEM) education outcomes for students in grades four through nine in rural, economically distressed, and/or tobacco-dependent counties of North Carolina. This work is especially important for those populations of students who historically have been under-represented in STEM areas, including females, students of color, and students living in poverty (Beede et al., 2011; Griffith, 2010; Leggon, 2006). North Carolina’s economy is in need of skilled workers in STEM fields — companies are relocating, jobs are opening-up, and the North Carolina Commission on Workforce Development predicts that this trend will continue (2011).

A special program of the Golden LEAF Board of Directors, the STEM Initiative targets projects that:

- Are evidence-based and represent systemic approaches to STEM education, including in-school, out-of-school, or extended day and support programs providing assistance to students transitioning from elementary to middle and middle to high school.
- Represent collaborations among public schools and higher education, community, and relevant industry partners.
- Target improved preparation for and academic performance in advanced STEM curricula by minorities, females, and students from limited-resource families.
- Serve students in 4th through 9th grades, placing priority on curricular approaches that are integrated, use project- and inquiry-based learning concepts, and/or prepare students for successful completion of Algebra I by 8th or 9th grade – a gateway to participation in advanced placement courses.
- Include strategies that are comprehensive, incorporate content specific professional development for teachers, and provide relevant career and work connections for teachers and students.

In the spring of 2011 the board made awards totaling $5 million to 14 grantees. These three-year projects received varying amounts, the smallest grant was $100,000 to support a single-district project and the largest award was $600,000 to aid a regional collaboration. In total, these grants impact 225 schools, roughly 1,190 teachers, and approximately 31,890 students in 43 public school districts in North Carolina (see Figure 1). Brief descriptions of the grants can be found in Appendix A.

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The Structure and Purpose of the Evaluation of the Golden LEAF STEM Initiative

The evaluation of the Golden LEAF STEM Initiative will take place over the three-year grant implementation period, from 2011 through 2014. The research is being conducted by the Consortium for Educational Research and Evaluation–North Carolina (CERE–NC), a partnership of the SERVE Center at the University of North Carolina at Greensboro, the Carolina Institute for Public Policy at the University of North Carolina at Chapel Hill, and the Friday Institute for Educational Innovation at North Carolina State University. This work does not closely examine one, single program’s strategies and outcomes. Instead, the Golden LEAF STEM Initiative evaluation operates at the initiative-level, exploring the common strategies and common outcomes across all 14 grantees. The purpose of the evaluation is to provide useful information to Golden LEAF as it seeks to better understand the impact of the initiative as a whole, and also to the grantees as they build their programs.

Evaluation Objective 1:

The first objective of the evaluation is to describe the overall effectiveness of the Golden LEAF STEM Initiative in achieving its goal of improving STEM education outcomes for 4th through 9th graders in rural North Carolina. For this purpose quantitative and qualitative data is being collected from multiple sources in three separate time periods: September 2011 through April 2012 (completed), September 2012 through April 2013, and September 2013 through February 2014. The results from these three periods of data collection are synthesized and compared annually, assessing ongoing impacts.

Data are collected in order to answer four, primary evaluation questions:
To what degree or in what ways were the Golden LEAF STEM Initiative grantees as a whole:

1. Faithful in implementing their STEM program’s criteria and goals?
2. Effective in changing student STEM attitudes?
3. Effective in changing student STEM learning?
4. Effective in changing teachers’ instructional practices?

**Evaluation Objective 2:**

The second objective of the Golden LEAF STEM Initiative evaluation is to provide resources and support to the grantees as they work to continually improve their individual programs. The evaluation team assists each of the grantees to:

- Develop and apply knowledge about education program evaluation; and
- Collect, interpret, and use formative data to improve their STEM programs.

Over the course of the three-year initiative various capacity-building events and activities take place: annual evaluation institutes, semi-annual webinars, the ongoing provision of formative data, access to online surveys, and access to one-on-one technical assistance from members of the evaluation team.

**Structure of this Report**

This report is the second in a series of two baseline data reports for the Golden LEAF STEM Initiative evaluation. These initial results establish a baseline against which to compare change over time in student STEM learning and teachers’ instructional practices.

The first baseline report was completed in April 2012 and contained results from data collected from September 2011 through February 2012 (Corn, Faber, Howard, Lauen, & Gaddis, 2012). Analyses of a North Carolina administrative dataset for the 2009-10 school year revealed, among other trends, that grantee schools have lower minority populations and also have higher poverty rates compared to all other schools in the state. Results from the pilot Golden LEAF STEM Implementation Rubric, a program-level self-assessment, showed that grant leaders reported their schools or grants have the most success in: using STEM education research to improve their work, supporting teachers to collaboratively develop assessments, providing students opportunities to work in teams, communicating their STEM education plan with key stakeholders, and providing credit completion availability at the high-school level. Leaders reported that their schools or grant could focus on increasing: the frequency of project-based learning, the depth of STEM content integration, the frequency of opportunities for students and teachers to interact with STEM industry professionals, and the amount of information about STEM careers shared with teachers and counselors. Formative results from five focus groups with participating teachers and 14 interviews with grant coordinators were also summarized in the April 2012 Baseline Report. Lastly, the first baseline report described the evaluation capacity-building activities that had been provided up to that point in time.
The current report extends that earlier work. This paper addresses evaluation questions 2-4, summarizes results from surveys administered to over 600 teachers and almost 10,000 students participating in the initiative, and examines results from all site visits conducted at participating schools. Additionally, the report describes the evaluation capacity-building efforts that have taken place since February 2012. The document concludes with reflections on Year 1 of the initiative. The report is divided into five sections: Data and Analysis, Findings, Capacity-Building Activities, Recommendations, and Next Steps.

I. Data and Analysis

This report describes results from various types of data collected from November 2011 through May 2012, including site visits, focus groups, classroom observations, surveys, and the STEM program implementation rubric. The data were collected from participating grant coordinators, teachers, and students and are described in more detail below.

Site Visits

From December 2011 through May 2012 the evaluation team made thirteen⁴, single-day site visits to either one or two participating schools in each Golden LEAF STEM Initiative grant. On these site visits evaluation team members visited classrooms of teachers participating in the initiative, conducted a focus group with participating teachers, and, when possible, had informal conversations with grant coordinators about their project’s progress. Grant coordinators planned the logistics of the site visit activities and all activities were carried-out according to these pre-arranged schedules.

Focus Groups with Participating Teachers

Conducting focus groups enables the evaluation team to hear the perspectives of participating teachers on STEM education and to learn of their experiences with the Golden LEAF STEM Initiative. The conversations were held during the in-person site visits and lasted for approximately one hour. The size of the focus groups ranged from one to ten teachers selected by the grant coordinator, with an average of five teachers per group. In total, 13 focus groups were conducted with 66 teachers. Grant coordinators chose the participants from either one school or from multiple schools participating in their Golden LEAF STEM Initiative grant. The arrangement depended on the size of the grant, the geographic locations of the schools, and the site visit schedule.

⁴ One grant spent Year 1 conducting asset-mapping, garnering stakeholder buy-in, and selecting schools, therefore no formal site visit was made to this grant during this data collection period. Implementation in classrooms is scheduled to begin in the 2012-13 school year.
The focus group protocol was developed by the evaluation team based upon the goals of the Golden LEAF STEM Initiative and the Year 1 implementation plans of grantees. Questions were written in an open-ended style and asked teachers about:

- Their perceptions related to the contemporary meaning of STEM education;
- What they know of the Golden LEAF STEM Initiative grant in their school or district;
- Changes they noticed in their students’ interests or learning in STEM;
- What works well in their school’s efforts to improve STEM education;
- What are challenges to improving STEM education.

The complete protocol can be found in Appendix B. Conversations were digitally recorded, transcribed, and imported into Atlas.ti software for further analysis. Results were coded using a grounded theory method for analysis (Glaser & Strauss, 1967), extracting codes from the text and then grouping them into categories and themes.

**Classroom Visits**

Each site visit also included approximately two to four hours of attendance in classrooms of participating teachers by evaluation team members. The visits were made in order to gather general information about the types of STEM activities, curricula, and instructional methods that were taking place in participating schools. Attendance by evaluation team members was held according to a pre-arranged schedule, with grant coordinators selecting the specific classrooms and class periods. A total of 22 different classrooms were visited. Typically two participating teachers’ rooms were visited for about one-two hours each. If two evaluation team members were present, each team member visited a single teacher’s classroom, and in other cases the same evaluation team member would observe both rooms. Evaluation team members took descriptive notes on the classroom agenda and used the Classroom Assessment Scoring System™ (CLASS) instrument in order to collect similar data across all classrooms. The CLASS protocol measures a general set of observed classroom behaviors and activities on a seven-point scale and is completed in 15 minute intervals. Descriptive notes and CLASS results were downloaded into Excel and were analyzed for general themes and patterns.

**Pilot Teacher Attitudes toward STEM Surveys**

Each of the five pilot surveys, the Science, Technology, Engineering, Mathematics, and Elementary Teacher Attitudes toward STEM Surveys, contains two scales, or sets of survey items which most confidently describe a single characteristic of the survey-taker when the

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5 This protocol is being used in multiple, national-level, education studies including the Bill & Melinda Gates Foundation’s Measures of Effective Teaching (MET) project (Kane & Staiger, 2012). Golden LEAF STEM Initiative evaluation team members received training on the use of the instrument and have received certification of their reliability. For more information on the CLASS instrument see: [http://www.teachstone.org/about-the-class/](http://www.teachstone.org/about-the-class/)

6 Due to the timing of the visits, two site visits did not allow the evaluation team to observe specific grant activities. In these cases the evaluation team observed other aspects of the STEM instruction of the participating teachers.
responses to these items are calculated as a single result. The first scale, the Personal STEM Teaching Efficacy Belief Scale (PSTEBS), consists of 12 Likert-scale questions which ask the respondent about their confidence in their teaching skills. The PSTEBS asks respondents to indicate their level of agreement with statements such as, “I am continually improving my [content area] practice,” and “I am confident that I can answer students’ [content area] questions.” The second scale, the STEM Teaching Outcome Expectancy Scale (STOES), also consists of 12 questions and asks the respondent about the degree to which they believe students’ learning can be impacted by effective teaching. The STOES asks respondents to indicate their level of agreement with statements such as, “The inadequacy of a student’s [content area] background can be overcome by good teaching,” and “The teacher is generally responsible for students’ learning in [content area].” The full versions of the pilot Science, Technology, Engineering, Mathematics, and Elementary Teacher Attitudes toward STEM Surveys can be found in Appendix C.

Development of the teacher surveys

The first drafts of the five surveys were created in the spring of 2011 by Friday Institute staff on the Maximizing the Impact of STEM Outreach (MISO) research project, funded by the National Science Foundation. From late summer through December of 2011 the Golden LEAF STEM Initiative evaluation team collaborated with the MISO project team to continue to develop the surveys. From December 2011 through February 2012 the Golden LEAF STEM Initiative grantees administered the pilot surveys to participating teachers and students (see below), along with an open-ended question asking the respondents for suggestions on how the survey could be improved. From March through August 2012, these survey results and also feedback on the surveys from other STEM education researchers were used by the Golden LEAF STEM Initiative evaluation team and the MISO project staff to develop the surveys further. Validity and reliability analyses were conducted to determine: if the individual survey items behaved as they were intended; if the items added to the explanatory power of the survey; if the scales actually functioned as single units; if the scales functioned similarly across different types of teachers; and overall what, if any, edits were needed to improve the accuracy and consistency with which the surveys measure STEM teachers’ confidence and beliefs about effective teaching. Overall, the results were very positive and showed that the scales were strong and clear with high reliability after dropping just a few items.

Administration of the teacher surveys

From early December 2011 through February 2012 the coordinators of the 14 Golden LEAF STEM Initiative grants administered online the pilot Science, Technology, Engineering, Mathematics, and Elementary Teacher Attitudes toward STEM Surveys can be found in Appendix C.

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7 The pilot Elementary Teacher Attitudes toward STEM Survey actually contains four scales – it combines the pilot mathematics and pilot science teacher surveys since the vast majority of elementary teachers instruct both subjects.
8 Likert-scale survey items ask respondents to report the degree to which they agree or disagree with a given statement. Both the PSTEBS and STOES scales ask respondents to rate their level of agreement on a five-point response-scale ranging from “strongly disagree” (1) to “strongly agree” (5).
9 See the Golden LEAF STEM Initiative Evaluation Baseline Report (Corn et al., 2012) for a more complete description of the survey development process.
Mathematics, and Elementary Teacher Attitudes toward STEM Surveys. The grant coordinators gave the surveys to teachers impacted by their program during the 2011-2012 school year. These baseline data were collected to provide early data that can be compared against results collected in subsequent years of the initiative and to test the pilot surveys. Unique URLs for each survey were given to the coordinators who managed the administration for their grant, either sending the links directly to participating teachers or sending the URLs to principals who then administered the surveys to participating teachers. Due to the limited time frame of the administration, not all grants were able to administer the surveys at an ideal time in their implementation process. Results, therefore, should be interpreted with some caution now and in future comparisons. Table 1 shows the initiative’s response rates by survey.

Table 1

<table>
<thead>
<tr>
<th>Teacher Attitudes toward STEM Survey</th>
<th>Number of Responses</th>
<th>Estimated Teachers Impacted in 2011-12</th>
<th>Estimated Response Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elementary</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Science</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Technology</td>
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<td></td>
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<tr>
<td>Engineering</td>
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<td></td>
</tr>
<tr>
<td>Math</td>
<td>118</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>643</td>
<td>700</td>
<td>92%</td>
</tr>
</tbody>
</table>

Note. The number of estimated teachers impacted in 2011-12 and the estimated response rate are based on actual and estimated impact figures provided by grantees. The number of responses includes those which may have subsequently been dropped prior to analysis (e.g. English teachers who took the science teacher survey).

Survey results have been analyzed at the scale-level using mostly descriptive statistics and independent comparisons by gender, race/ethnicity, subject area, National Board Certification, and school-level. Some analyses were completed at the item-level as well.

Results from the pilot teacher survey items that have been removed from the final versions of the surveys (which will be ready for online administration in September 2012) were dropped from analyses in order to increase the accuracy of this report’s findings.

Pilot Student Attitudes toward STEM Surveys

The pilot Upper Elementary (4-5th) and the pilot Middle and High School (6-12th) Student Attitudes toward STEM Surveys are two, grade-level specific versions of the same survey. The pilot survey items are written at different reading-levels specific to the age-level of the respondents, but are intended to measure the same perceptions of the students. The pilot surveys contain four scales and one additional section. The first scale measures student attitudes toward mathematics. It consists of eight Likert-scale questions which ask the respondent about their confidence and interest in mathematics, including questions such as, “I am the type of student
who does well in math,” and “When I’m older, I might choose a job that uses math.” The second, third, and fourth scales measure student attitudes toward science, technology and engineering, and 21st century skills such as communication and collaboration. The final section of the survey asks students about their levels of interest in 12 STEM career areas. Full versions of the Upper Elementary School and Middle/High School S-STEM Surveys can be found in Full versions of the pilot Upper Elementary and Middle and High School Student Attitudes toward STEM Surveys can be found in Appendix D.

Development of the student surveys

Initial drafts of both the Upper Elementary and the Middle and High School Student Attitudes toward STEM Surveys were created in the spring of 2011 by the MISO project team. Through the fall and winter of 2011 and 2012 the Golden LEAF STEM Initiative evaluation partnered with the MISO staff to develop the student surveys further. Similar validity and reliability analyses were conducted on the two pilot student surveys as were done on the pilot teacher surveys, using the results from the December 2011 – February 2012 Golden LEAF STEM Initiative administration. Suggestions for survey improvements from respondents and feedback from STEM education researchers were also used to edit the surveys. Finally, also like the pilot teacher surveys, the results from these analyses showed that the scales in the student surveys were strong and clear with high reliability after dropping just a few items.

Administration of the student surveys

From early December 2011 through February 2012 coordinators for the 14 Golden LEAF STEM Initiative grants administered online the pilot Upper Elementary and Middle and High School Student Attitudes toward STEM Surveys. The grant coordinators gave the surveys to those students impacted by their grants during the 2011-2012 school year. This baseline data was collected to provide early data that can be compared against results collected in subsequent years of the initiative and to test the pilot surveys. Unique URLs for each survey were given to grant coordinators who then managed the administration for their grant, either sending the links to directly to participating teachers who then administered them to their students, or sending the URLs to principals who shared the links. Due to the limited time frame of the administration, not all grants were able to administer the surveys at an ideal time in their implementation process. Results, therefore, should be interpreted with some caution now and in future comparisons. Table 2 shows the initiative’s response rates by survey.

10 The S-STEM scales ask student respondents to rate their level of agreement on a five-point Likert-scale ranging from “strongly disagree” (1) to “strongly agree” (5).
11 See the Golden LEAF STEM Initiative Evaluation Baseline Report (Corn et al., 2012) for a more complete description of the survey development process.
Table 2

Initiative Student Response Rates, December 2011-February 2012

<table>
<thead>
<tr>
<th>Student Attitudes toward STEM Survey</th>
<th>Number of Responses</th>
<th>Estimated Students Impacted in 2011-12</th>
<th>Estimated Response Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Elementary School (4-5th)</td>
<td>967</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle and High School (6-12th)</td>
<td>9,481</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>10,448</td>
<td>12,800</td>
<td>82%</td>
</tr>
</tbody>
</table>

Note. The number of estimated students impacted in 2011-12 and the estimated response rate are based on actual and estimated impact figures provided by grantees. The number of responses includes those which may have subsequently been dropped prior to analysis (e.g. 3rd graders who took the upper elementary student survey).

Similarly to the teacher survey findings, results from the student surveys have been analyzed at the scale-level using mostly descriptive statistics and independent comparisons by gender, race/ethnicity, and school-level. Some analyses were completed at the item-level as well.

Responses to the pilot student survey items that have been removed from the final versions of the surveys (which will be ready for online administration in September 2012) were dropped from analyses in order to increase the accuracy of this report’s findings.

Pilot Golden LEAF STEM Implementation Rubric

Development of the rubric

In the fall of 2011 the Golden LEAF STEM Initiative evaluation team developed the pilot Golden LEAF STEM Implementation Rubric. Its primary purpose is to support project leaders to reflect on the depth and breadth of their program’s implementation. The rubric aims to articulate a common language for STEM program implementation strategies and to establish a continuum describing good-to-great STEM programs. While it serves as a reflective resource for the grantees as they plan, evaluate, and adjust their own STEM education programs, it also acts as a useful measurement instrument for the evaluation of the Golden LEAF STEM Initiative overall. The rubric has also shown promise in aiding philanthropic organizations in evaluating proposed projects and allocating scarce resources by identifying projects that demonstrate “readiness” to implement with fidelity.

The Golden LEAF STEM Implementation Rubric’s framework consists of 11 overarching “attributes” of a successful STEM program. In the fall of 2011 these attributes were identified by the North Carolina Department of Public Instruction and adopted by the North Carolina State Board of Education as part of their larger statewide STEM Education Strategy. The attributes encompass a wide range of qualities of successful STEM programs, from the application of

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12 See the Golden LEAF STEM Initiative Evaluation Baseline Report (Corn et al., 2012) for a more complete description of the rubric development process.
Golden LEAF STEM Initiative
August 2012

project-based learning across all STEM subjects to the communication of a STEM education plan to local education, business, and civic communities. In the rubric, represented within each attribute, are three to five “key elements” calibrated along a four-item scale from “early” to “developing” to “advanced” to “target.” Users of the rubric assess the depth of their STEM program’s implementation according to these key elements. These components pertain to school-wide programs, so for users reflecting on programs that are not school-wide, not all key elements will be valid measures of their implementation. In these cases, however, the key elements can be useful descriptions of the program’s environment. The full version of the pilot Golden LEAF STEM Implementation Rubric, along with the aggregate results from its first administration, can be found in Appendix E.

STEM education leaders in North Carolina were actively engaged in providing constructive feedback during the drafting of the pilot Golden LEAF STEM Implementation Rubric. Since that time, the rubric has been administered to the grant coordinators and feedback on the instrument was received from those early users. Additionally, the Golden LEAF STEM Initiative evaluation team received edits and feedback from experts at North Carolina State University’s College of Education and the North Carolina Department of Public Instruction received edits and feedback from various administrators and teachers across the state. The feedback from all these stakeholders will be taken together with results from the first administration to the 14 grants and used to further improve the rubric by fall of 2012. These important revisions will increase the instrument’s validity and reliability prior to its second administration to the STEM initiative grantees in winter 2012.

Administration of the rubric

From early November 2011 through late January 2012 grant coordinators of the 14 grants used the pilot rubric to assess their program’s depth of implementation along each of the STEM Attributes. The coordinators were encouraged to work with their grant’s leadership team to identify where on the implementation continuum they believed their program to be operating for each relevant key element. The coordinators frequently provided additional, clarifying notes.

Administrative Data on Student Performance

Often state-level standardized tests are not sensitive enough to measure changes in learning that result from a single change in a student’s total experience. For these reasons, the Golden LEAF STEM Initiative evaluation plan has scheduled to collect standardized test results at two points in time: at the beginning of the initiative and at the end of the initiative. The Golden LEAF STEM Initiative Evaluation Baseline Report (Corn et al., 2012) summarized administrative data on student achievement from the 2009-10 school year, reporting mostly school-level percent proficiency on standardized tests for participants in the Golden LEAF STEM Initiative. Similar data will be collected in 2014 at the conclusion of the evaluation and will be compared against the baseline results. Administrative data on student performance were not collected for this report.
II. Findings

This report addresses evaluation questions 2-4 by summarizing results from surveys administered to over 600 teachers and almost 10,000 students participating in the initiative, and results from the 13 site visits to participating schools.

To what degree or in what ways were the Golden LEAF STEM Initiative grantees as a whole effective in changing student attitudes toward STEM education?

Student characteristics

In order to better understand the students participating in the initiative, items on the pilot Upper Elementary and Middle and High School Student Attitudes toward STEM Surveys ask students to share information about their background, including gender, race/ethnicity, performance expectations, intentions for college, and personal knowledge of adults in STEM careers (Tables 3-5).

Analyses of the demographic characteristics of student respondents show that the proportions of participating students by both gender and race/ethnicity were similar to the proportions of these students in Golden LEAF STEM Initiative schools overall (see April 2012 baseline report). A smaller percentage of Black/African American students, however, responded to the student attitudes survey (9.9%) than were enrolled in Golden LEAF STEM Initiative schools overall in the 2009-10 school year (13.3%).

Due to the small number of respondents (25), Native Hawaiian/Pacific Islander students are not included in the remaining analyses.

Table 3
Upper Elementary and Middle and High School Student Demographic Characteristics

<table>
<thead>
<tr>
<th>Demographic Characteristic</th>
<th>Percentage of Respondents</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Upper Elementary (n=774)</td>
<td>Middle School (n=7,855)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>50.9%</td>
<td>50.3%</td>
</tr>
<tr>
<td>Female</td>
<td>49.0%</td>
<td>49.6%</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>American Indian/Alaska Native</td>
<td>9.9%</td>
<td>6.9%</td>
</tr>
<tr>
<td>Asian</td>
<td>0.4%</td>
<td>3.0%</td>
</tr>
<tr>
<td>Black/African American</td>
<td>7.6%</td>
<td>8.9%</td>
</tr>
<tr>
<td>Hawaiian/Other Pacific Islander</td>
<td>0.6%</td>
<td>0.6%</td>
</tr>
<tr>
<td>White/Caucasian</td>
<td>69.6%</td>
<td>70.7%</td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>6.5%</td>
<td>9.3%</td>
</tr>
</tbody>
</table>
Note: Respondents were able to select more than one race/ethnicity; percentage totals for middle and high school students by race/ethnicity are slightly greater than 100%. Upper elementary results include students in grades 4-5; middle school results include students in grades 6-8; and high school results include students in grades 9-12.

Results from the baseline administration of the student surveys show that students overall had moderate to high expectations for their performance in their English, science, and math classes this year (Table 4).

Table 4
Upper Elementary and Middle and High School Student Performance Expectations by Subject

<table>
<thead>
<tr>
<th>“How well do you expect to do this year in your …”</th>
<th>Percentage of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n=9,324)</td>
</tr>
<tr>
<td></td>
<td>Not Very Well</td>
</tr>
<tr>
<td>Math Class</td>
<td>8.9%</td>
</tr>
<tr>
<td>Science Class</td>
<td>8.0%</td>
</tr>
<tr>
<td>English Class</td>
<td>6.3%</td>
</tr>
</tbody>
</table>

Students varied only slightly in performance expectations when compared by gender, race/ethnicity, or school-level (see Appendices F-H for complete student survey results by survey item and by demographic characteristics). In regards to their performance in English class, female students were slightly more confident (95.1% responded “OK/Pretty well” or “Very Well”) than males (92.3%); American Indian/Alaska Native students were slightly less confident in their performance (88.7%) than others (93.7% on average); and elementary students were slightly less confident (90.5%) than their middle (93.7%) and high school (96.4%) counterparts.

Female and male students had very similar expectations when asked how well they thought they would perform in science class (92.2% of male students responded “OK/Pretty Well” or “Very Well” compared to 91.9% of female students). When compared by race/ethnicity, students varied only slightly in their performance expectations for science class. White/Caucasian students expressed the highest expectations for their performance in science class (92.9% responded “OK/Pretty Well” or “Very Well”) and Hispanic/Latino students had the lowest expectations (89.1%).

Finally, in math class, students’ levels of confidence were mixed. Female and male students differed by less than one percentage point. Asian students had the highest expectations (94.1% responded “OK/Pretty Well” or “Very Well”) and American Indian/Alaska Native students had the lowest expectations (89.3%). Students varied slightly by school-level: elementary students had the most confidence (92.9% responded “OK/Pretty Well” or “Very Well”) and high school students had the least confidence (88.1%).

Results from the surveys show several other trends (Table 5):
Middle school students were more likely to plan to go to college (86.6%) than high school students (80.0%); On average, older students were more likely to know adults who work as scientists and engineers than younger students (proportions decreased from high, to middle, to elementary school; and On average, students were more likely to know an adult who works as an engineer (58.2%) than an adult who works as a mathematician (41.4%) or as a scientist (25.5%).

Table 5
Upper Elementary and Middle and High School Student STEM Education Characteristics

<table>
<thead>
<tr>
<th>Survey Item</th>
<th>Percentage of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Upper Elementary</td>
</tr>
<tr>
<td></td>
<td>(n=744)</td>
</tr>
<tr>
<td>Do you plan to go to college?</td>
<td>--</td>
</tr>
<tr>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Yes, I know an adult who works as a/an ...</td>
<td></td>
</tr>
<tr>
<td>Engineer</td>
<td>57.0%</td>
</tr>
<tr>
<td>Scientist</td>
<td>19.4%</td>
</tr>
<tr>
<td>Mathematician</td>
<td>32.4%</td>
</tr>
</tbody>
</table>

Note: Upper elementary results include students in grades 4-5; middle school results include students in grades 6-8; and high school results include students in grades 9-12.

Student outcomes

The Golden LEAF STEM Initiative grantees all share the common objective of improving student attitudes toward STEM subjects and increasing their interest in STEM careers. Over time grantees hope that these changes will lead to an improvement in student performance in STEM classes and increased enrollments in advanced STEM courses. To help meet this objective, every grant’s main strategies include providing more opportunities for authentic, hands-on learning in STEM subjects, such as providing problem-based math curricula or opportunities to build structures in science class or program machines in an elective.

Student engagement. During focus groups participating teachers reported more frequently than any other outcome that student engagement in STEM increased as a result of the hands-on activities provided through the Golden LEAF STEM Initiative. Every focus group conversation revealed this finding. Some direct quotes from teachers illustrate this point:

Some of [the students] seem really excited to come. It’s very different than anything they’ve ever done before. They get upset if class is cancelled. They’d rather come here than to gym – that’s saying something!
It’s just one of those things – you don’t know what you’re missing until you’ve seen it. And so for a lot of these students, they never had a clue as to what they were missing until they came into the classroom. They see it and are like, “Wow, that’s really cool. I never knew I could do it.”

I think that their attitudes toward going into the fields of science, technology, engineering, and math have changed because when they come in they’re saying, “I’m not sure what I want to do,” and later they say, “Wow. Maybe I want to do this. Maybe I want to investigate this,” and they ask “What can I do at the high school?”

Results from classroom visits support this finding as well. Student behaviors that demonstrate high levels of engagement were seen during all but one, 15-minute observation period out of 58 total periods observed across the initiative.

Despite these high levels of engagement when participating in hands-on activities, combined baseline data from the pilot student surveys show that in general students overall slightly agreed that they felt confident in their abilities and were interested in STEM content (see Table 6). Variation between students at different school-levels was very slight, but upper elementary school students did report the most confidence and interest, or most positive attitudes, toward mathematics, science, and engineering and technology. High school students reported the least positive attitudes, and middle school students’ attitudes toward STEM subjects fell between the two. See appendices F-H for complete student survey results by survey item and by demographic characteristics.

Table 6
Mean Composite Scores of Upper Elementary and Middle and High School Student STEM Attitudes by School-level

<table>
<thead>
<tr>
<th>STEM Attitudes</th>
<th>Upper Elementary (n=785)</th>
<th>Middle School (n=7,698)</th>
<th>High School (n=926)</th>
<th>All students (n=9,409)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math Attitudes</td>
<td>3.7</td>
<td>3.6</td>
<td>3.4</td>
<td>3.6</td>
</tr>
<tr>
<td>Science Attitudes</td>
<td>3.6</td>
<td>3.4</td>
<td>3.4</td>
<td>3.4</td>
</tr>
<tr>
<td>Engineering and Technology Attitudes</td>
<td>3.5</td>
<td>3.4</td>
<td>3.3</td>
<td>3.4</td>
</tr>
</tbody>
</table>

Note: Responses were recorded on a five-point Likert scale: “strongly disagree” (1), “disagree” (2), “neither agree nor disagree” (3), “agree” (4), and “strongly agree” (5). Upper elementary results include students in grades 4-5; middle school results include students in grades 6-8; and high school results include students in grades 9-12.

Industry connections. The pilot student surveys measure students’ interests in various STEM career areas as well (Table 7). Overall the greatest proportion of students indicated that they were “interested” or “very interested” in veterinary work (51.4%), while the smallest proportion of students reported that they were interested or very interested in careers in physics (29.8%). Except for biology, the five career areas in which students expressed the most interest (veterinary work, medicine, engineering, biology and zoology, and medical science) are fields for which public school courses are rarely offered.
Comparisons between male and female students also reveal some interesting trends. Overall male and female students expressed a similar level of interest in STEM careers as a whole (42.6% and 38.9% on average), but their interests vary significantly within several fields. For example, 71.2% of male students were interested or very interested in careers in engineering while only 28.1% of females were. Other career fields for which male and female students reported significantly different interest-levels included: veterinary work (males: 36.4%, females: 66.6%), energy (males: 47.0%, females: 19.1%), medicine (males: 38.8%, females: 61.6%), and computer science (males: 49.2%, females: 25.5%). Females expressed the most interest in veterinary work (66.6%), medicine (61.6%), biology and zoology (54.6%), and medical science (50.3%). Males, on the other hand, reported the most interest in engineering (71.2%), computer science (49.2%), energy (47.0%), and biology and zoology (41.3%).

Also notable is the fact that there were no STEM fields for which male students, as a whole, expressed interest levels lower than a 30% proportion being “interested/very interested.” Female students, however, had interest levels lower than a 30% proportion being “interested/very interested” in four career fields: engineering, computer science, energy, and physics.

Table 7
*Upper Elementary and Middle and High School Student Interest in STEM Careers – All Students and by Gender*

<table>
<thead>
<tr>
<th>Career Area</th>
<th>Proportion “Interested/Very Interested”</th>
<th>All Students (n=9,412)</th>
<th>Male (n=4,723)</th>
<th>Female (n=4,685)</th>
<th>Difference - Male, Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Veterinary Work</td>
<td></td>
<td>51.4%</td>
<td>36.4%</td>
<td>66.6%</td>
<td>30.2%</td>
</tr>
<tr>
<td>Medicine</td>
<td></td>
<td>50.2%</td>
<td>38.8%</td>
<td>61.6%</td>
<td>22.8%</td>
</tr>
<tr>
<td>Engineering</td>
<td></td>
<td>49.7%</td>
<td>71.2%</td>
<td>28.1%</td>
<td>43.1%</td>
</tr>
<tr>
<td>Biology &amp; Zoology</td>
<td></td>
<td>47.9%</td>
<td>41.3%</td>
<td>54.6%</td>
<td>13.3%</td>
</tr>
<tr>
<td>Medical Science</td>
<td></td>
<td>42.2%</td>
<td>34.1%</td>
<td>50.3%</td>
<td>16.2%</td>
</tr>
<tr>
<td>Chemistry</td>
<td></td>
<td>37.7%</td>
<td>41.2%</td>
<td>34.2%</td>
<td>7.0%</td>
</tr>
<tr>
<td>Environmental Work</td>
<td></td>
<td>37.5%</td>
<td>36.5%</td>
<td>38.5%</td>
<td>2.0%</td>
</tr>
<tr>
<td>Computer Science</td>
<td></td>
<td>37.4%</td>
<td>49.2%</td>
<td>25.5%</td>
<td>20.7%</td>
</tr>
<tr>
<td>Mathematics</td>
<td></td>
<td>36.8%</td>
<td>39.8%</td>
<td>33.9%</td>
<td>5.9%</td>
</tr>
<tr>
<td>Earth Science</td>
<td></td>
<td>35.1%</td>
<td>37.2%</td>
<td>33.0%</td>
<td>4.2%</td>
</tr>
<tr>
<td>Energy</td>
<td></td>
<td>33.1%</td>
<td>47.0%</td>
<td>19.1%</td>
<td>27.9%</td>
</tr>
<tr>
<td>Physics</td>
<td></td>
<td>29.8%</td>
<td>38.2%</td>
<td>21.3%</td>
<td>16.9%</td>
</tr>
</tbody>
</table>

*Note:* Bold percentages indicate differences between males and females greater than 15 percentage points. Responses were recorded on a four-point Likert scale: “not at all interested” (1), “somewhat interested” (2), “interested” (3), and “very interested” (4).

The differences in levels of interest in STEM careers between students of different races/ethnicities are smaller than the differences between male and female students (Table 8). Asian students had the largest, average level of interest in STEM careers (47.0%) and White/Caucasian students and Black/African American students had the smallest average levels of interest (39.8% and 40.0% respectively). The largest differences in interests were in: biology
and zoology, in which Asian students had the most interest (57.8%) and Black/African American students had the least interest (36.3%); medicine, in which Asian students had the most interest (60.1%) and American Indian/Native Alaskan students had the least interest (43.0%); and chemistry, in which Asian students again had the most interest (51.9%) and White/Caucasian students had the least interest (35.8%).

Table 8
Upper Elementary and Middle and High School Student Interest in STEM Careers by Race/Ethnicity

<table>
<thead>
<tr>
<th>Career Area</th>
<th>Proportion “Interested/Very Interested”</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>American Indian/AK Native (n=481)</td>
</tr>
<tr>
<td>Physics</td>
<td>29.7%</td>
</tr>
<tr>
<td>Environmental Work</td>
<td>40.5%</td>
</tr>
<tr>
<td>Biology &amp; Zoology</td>
<td>49.5%</td>
</tr>
<tr>
<td>Veterinary Work</td>
<td>52.9%</td>
</tr>
<tr>
<td>Mathematics</td>
<td>37.8%</td>
</tr>
<tr>
<td>Medicine</td>
<td>43.0%</td>
</tr>
<tr>
<td>Earth Science</td>
<td>37.8%</td>
</tr>
<tr>
<td>Computer Science</td>
<td>35.7%</td>
</tr>
<tr>
<td>Medical Science</td>
<td>38.5%</td>
</tr>
<tr>
<td>Chemistry</td>
<td>37.3%</td>
</tr>
<tr>
<td>Energy</td>
<td>39.3%</td>
</tr>
<tr>
<td>Engineering</td>
<td>53.8%</td>
</tr>
<tr>
<td>Average</td>
<td>41.3%</td>
</tr>
</tbody>
</table>

Note: Responses were recorded on a four-point Likert scale: “not at all interested” (1), “somewhat interested” (2), “interested” (3), and “very interested” (4).

It is also noteworthy that when comparing general STEM career interest by grade level, upper elementary school students had higher levels of interest across all career areas on average (49.2%) than both middle school students (40.4%) and high school students (37.1%). In fact, upper elementary school students expressed greater interest than middle and high school students in every career area except medicine. Full results on the students’ career interest by grade-level can be found in Appendix H.

These survey results fit the state and national trends that indicate students have moderate levels of interest in STEM careers. In order to reach the objective of increasing student interest in STEM subjects and careers, some of the 14 Golden LEAF STEM Initiative grants included in their program strategies opportunities for students to directly engage with STEM industry professionals. These activities included tours of regional STEM industry facilities, opportunities for students to hear STEM industry professionals speak about their work, and, in the case of one grant, elective activities in which students used professional-grade equipment for projects and
competitions. In general teachers reported that these opportunities were very beneficial for students. One teacher explained how these opportunities can help increase student interest:

*I would like to bring in outside sources, experts in my area ... people who’d be willing to come and share how they use this content in their field. I think they would get a more meaningful connection with the students ... Then when we study concepts like electricity, what could be better? We’ve got Energizer down the road. Those are the community things that we need to bring in.*

Another teacher described how authentic, hands-on experiences with industry problems and materials could make a strong impression on students:

*I’d like to see not so much more of speakers, but more of what people actually do that is job-related. That way the students can see a plant manager coming in and actually demonstrating and then saying, “I want you to do this. This is what you have to be able to do.” ... If they could get to just do hands-on activities with industries, like playing with a robot at a hospital – when they’re doing it, they’ll be able to understand concepts better I think.*

Considering the resources necessary to provide these kinds of opportunities, focus group participants did recognize the challenges. Teachers acknowledged the very limited financial resources in the public schools and a few teachers discussed how school schedules restrict their own ability to plan such opportunities. Other teachers mentioned that limited planning time makes it challenging for educators to organize collaborations with industry partners.

Results from the administration of the Golden LEAF STEM Implementation Rubric correlated with participating teachers’ sense that a limited number of opportunities for students to directly engage with STEM industries exist. Most grant coordinators and their teams (11 out of 13) rated their programs, schools, and/or districts as “early/developing” in the rubric’s “Students and STEM Professionals” key element (Attribute A2) – describing direct experiences with STEM professionals and STEM learning environments were either in the planning stages or available for students 1-2 times a year.

*Involving underrepresented students.* In addition to making industry connections, the Golden LEAF STEM Initiative aims to support programs focusing on students in groups underrepresented in STEM pathways and careers, especially females, students of color, and students from low socioeconomic backgrounds. Many grants are incorporating new curricula and hands-on activities in the full range of core classes, therefore reaching all students in grade-levels or in schools. Some grants are launching new STEM elective courses open to all students. A few projects are offering in- and out-of-school opportunities specifically for students in these underrepresented groups, including some special elective classes, activities in targeted schools, and summer camps. Using the STEM program implementation rubric and reflecting on their program, grant coordinators most frequently described the environment for inspiring underrepresented students (Attribute A6) as “developing.” The developing stage of this key element is described as a school or program that has “two or more in-school programs that inspire underrepresented students to be excited about STEM subjects and careers.”
Furthermore, participating teachers reported that the new learning opportunities provided with Golden LEAF STEM Initiative support positively impacted students who had previously shown little interest in STEM content. Multiple teachers described how the new STEM activities engaged students who typically struggled in their STEM classes; one educator described:

> I’ve had several students who had profound disabilities, [Exceptional Children] students, and they were able to create things, even though in the beginning they said, “I can’t do that. I can’t do that.” For example, [during a design activity] one student finally got the wood cut out and put it together, then I painted it for him. When the student got it back, completed, the [Exceptional Children] teacher told me the student was just ecstatic and he couldn’t believe that that was what he started with.

Another teacher who worked at a school with a population of students that come from mostly low socioeconomic backgrounds talked about the impact the hands-on, advanced STEM learning activities were having on some students:

> There are a lot of students that just simply hate school. They do not want to go to school. They don’t care about it. For them, it’s just a pain, something they have to do. But for a lot of those same students, when they come into this class, this is something they want to do. They want to come and they want to work on things.

Focus group conversations also revealed that some STEM teachers have begun noticing a change in the level of engagement from female students as well. A middle school teacher explained:

> I like what it’s done to the girls in my class, the science. Because generally, I’m speaking for myself, when I was a student in school I always thought science was a guy thing, that it wasn’t for girls. And watching these girls in these labs, they’re running over the guys and they’re offering ideas. They’re arguing, “No, it doesn’t work that way” and they’re hands-on. They’re not afraid. They’re not just sitting back and letting the boys do all the work. They are jumping in there … They know they have that opportunity to be heard and to try their own ideas.

Combined baseline data from the pilot Upper Elementary and Middle and High School Student Attitudes Surveys show that female students felt confident in their abilities and were interested in math and science at levels basically equivalent to males (Table 9). Female students did, however, have less positive attitudes (3.1) than males (3.7) toward engineering. These results correlate with findings from the careers section of the survey which show that female students have less interest in the engineering field than males.

<table>
<thead>
<tr>
<th>STEM Attitudes</th>
<th>Male (n=4,864)</th>
<th>Female (n=4,819)</th>
</tr>
</thead>
</table>

Table 9

Mean Composite Scores of Upper Elementary and Middle and High School Student STEM Attitudes by Gender

Consortium for Educational Research and Evaluation – North Carolina
Golden LEAF STEM Initiative
August 2012

<table>
<thead>
<tr>
<th></th>
<th>Math Attitudes</th>
<th>Science Attitudes</th>
<th>Engineering and Technology Attitudes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.6</td>
<td>3.5</td>
<td>3.4</td>
</tr>
<tr>
<td></td>
<td>3.4</td>
<td>3.4</td>
<td>3.7</td>
</tr>
</tbody>
</table>

Note: Responses were recorded on a five-point Likert scale: “strongly disagree” (1), “disagree” (2), “neither agree nor disagree” (3), “agree” (4), and “strongly agree” (5).

When students are compared by race/ethnicity, results from the student attitudes surveys show that students did not vary considerably in their confidence and interest in STEM subjects. Complete results on student attitudes toward math, science, and engineering and technology by race/ethnicity can be found in Appendix H.

To what degree or in what ways were the Golden LEAF STEM Initiative grantees as a whole effective in changing student STEM learning?

In addition to impacting student attitudes toward STEM subjects, the Golden LEAF STEM Initiative grantees aim to increase student learning in STEM as well. Projects are implementing authentic, hands-on learning opportunities in STEM topics aligned to the North Carolina Standard Course of Study. For many grants the new curricula and projects are not only engaging to students but also cover challenging material. For example, six grants include implementation of the Project Lead the Way (PLTW) curriculum as one of their strategies – PLTW covers advanced material in many topics, including measurement, engineering, and design with a core strategy of providing a “rigorous and innovative” STEM curriculum. Other grants are: implementing math curricula that teach real-world problems with hands-on materials; purchasing and using science kits and lab investigations; launching afterschool or summer STEM clubs and camps; and providing professional development for teachers on using instructional technology and problem-based teaching strategies.

Student Outcomes

Integrating subjects. Recognizing the importance of developing analytical skills in students, a key ability in the 21st century job market (MetLife & Harris Interactive, 2011; Symonds, Schwartz, & Ferguson, 2011), the Golden LEAF STEM Initiative seeks to support teaching and learning that integrates multiple content areas. The focus group protocol did not explicitly ask teachers about content integration, and yet teachers across several grants brought up the topic themselves. They discussed that they had noticed students making more frequent connections across subjects as a results of the new STEM curricula and activities. One teacher recalled:

I hear students say a lot “Oh, well I remember doing this in [teacher]’s class,” or “We did this last week in [teacher]’s math class,” or “This is a reading strategy taught in our English/language arts class.”

See http://www.pltw.org/about-us/who-we-are
Several focus group conversations indicated that the new curricula and teaching strategies have strong connections to reading. For example, teachers noted on multiple occasions that this work is directly connected to the new Common Core State Standards for English/language arts, which North Carolina schools begins implementing next year. The standards have a focus on reading informational texts:

*The Common Core is focusing so much on informational texts ... The reading the students are doing in science class through the kits is really good, so language arts could just count what I’m doing.*

A colleague concurred:

*I agree. There are some really good reading strategies in those. I really like those. It’s there, in the teachers’ manuals. You can say, “It’s informational reading, and the students just happen to be learning about plate tectonics.”*

Some of the science, technology, and engineering courses are able to provide relevancy for students in mathematics as well.

*It’s even interesting within a lesson when they figure out that this complicated formula that they learned in math class actually has an application and it actually can be used for this, and it actually provides something useful. It’s interesting how their opinion can change even within an hour and a half class period.*

Despite the early success integrating across subjects, there were reported challenges as well. Multiple teachers explained that students also frequently resisted integrating subjects. The educators contended that the students had grown accustomed to compartmentalizing content as they matriculated through school. For example, one teacher remembered an interaction with student:

*A question asked, “What do you think about the importance of mathematics in life sciences?”... A few of the students said, “I don’t think math is important to life sciences at all, in fact talking about math in science class just confuses me, and I think that [teacher] should be the only one who talks about math.”*

While the challenge to integrate content for some students was clear, the students were not the only ones who occasionally struggled with this challenge. A few focus group discussions touched-on the topic of teachers who resisted integrating subject-matter:

*I think some of us teachers are doing it, but not everyone in our building is on board with STEM. It’s a matter of getting everyone on board to tie in all those subjects together.*

Multiple focus group participants suggested that more peer collaboration time and support is needed to help educators overcome these challenges. They recommended that the first step teachers and schools take should be to enable faculty to share more easily information with each other about the material they are covering. Next schools should enable deeper collaboration
among teachers by providing them time to co-create lessons that thoughtfully integrate content and provide powerful learning opportunities for students. A Career and Technical Education (CTE) teacher put it this way:

*I wish that when they’re teaching whatever subject, like the environment, and we’re talking about the six forms of energy ... I wish that there was a way for us to go deeper between the classes, for the two of us work together on that. I don’t know how we’re going to do that, though, because I know that there are time constraints.*

Focus group results suggest that a majority of teachers feel positive about the future for integrating across subjects despite these challenges. They feel the idea is spreading throughout parts of the education system. An experienced educator shared:

*I’m an old dinosaur and I’m having to transform my way of teaching ... I think everybody realizes this day and time that you have to get on this boat because this is the way education is going.*

A teacher from another grant reflected:

*I think the integration has changed a lot. I mean, I probably haven’t been here long enough to know what’s been done in [school district], but, in general, it seems like integration in education is changing how we do everything and it’s making it easier for the kids to understand because they can learn everything together.*

Additionally, results from the administration of the STEM implementation rubric support the focus group results that some teachers are at the leading edge of a trend to increase content integration, and that there is room for others to follow. Leaders from nine grants reflected on their schools and districts and reported under Attribute A1 that up to 25% of the faculty members in their schools “make explicit efforts to integrate STEM across core subjects.” Another four grants estimated that between 25-50% of the faculty members at their schools make those efforts.

**Student collaboration.** The ability to communicate and collaborate with others is another important skill that students will need when they enter the 21st century workplace and adult life. Employers today also frequently cite these skills as key competencies for their staff (MetLife & Harris Interactive, 2011; Symonds, Schwartz, & Ferguson, 2011). Findings across data sources suggest that students participating in the Golden LEAF STEM Initiative have frequent opportunities to work together on meaningful tasks and are developing communication skills. Results from the pilot STEM Program Implementation Rubric show that, when asked about how often students work together in teams to frame problems and test solutions (Attribute B1), six grants rated themselves as “developing” and four grants rated themselves as “advanced.” During focus groups, when asked about what, if any, changes they have seen in students as result of grant activities, teachers from several grants indicated that they had noticed improvements in their students’ collaboration skills. On multiple occasions the educators discussed how the investigative labs and other small group activities included in the new curricula have forced the students to learn to work together in teams. One teacher captured it well:
There is more group work every day and they don’t get to pick who they’re paired with and it changes every time they change stations. So it’s kind of like a real job ... They have to be able to communicate effectively with this person because it’s not just their grade; it’s a group grade. I mean, they have individual accountability, of course, but there’s that teamwork aspect also.

Additionally, findings from the pilot Upper Elementary and Middle and High School Attitudes toward STEM Surveys suggest that students have the most positive attitudes toward 21st century learning skills as compared to their attitudes toward math, science, or engineering and technology (Table 10). Students varied very slightly in their attitudes toward 21st century skills when compared by gender (males: 3.9, females: 4.1) and almost not at all when compared by race/ethnicity (ranged 3.9 to 4.0). Students’ attitudes did not vary when compared by school-level (4.0). See Appendix F-H for full results on student attitudes toward 21st century learning.

Table 10
Upper Elementary and Middle and High School Student Attitudes toward 21st Century Learning Compared to other STEM Attitudes

<table>
<thead>
<tr>
<th></th>
<th>Mean Composite Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>21st Century Learning Attitudes</strong></td>
<td></td>
</tr>
<tr>
<td>All Students (n=9,686)</td>
<td>4.0</td>
</tr>
<tr>
<td>Math Attitudes</td>
<td>3.6</td>
</tr>
<tr>
<td>Science Attitudes</td>
<td>3.4</td>
</tr>
<tr>
<td>Engineering &amp; Technology Attitudes</td>
<td>3.4</td>
</tr>
</tbody>
</table>

Note: Responses were recorded on a five-point Likert scale: “strongly disagree” (1), “disagree” (2), “neither agree nor disagree” (3), “agree” (4), and “strongly agree” (5).

While survey results have the most explanatory power when considered as entire scales, a subset of the items in the student survey’s 21st Century Skills scale directly ask students about their communication and collaboration skills. Findings from these individual items indicate that, overall, upper elementary school students and middle and high school students had similar levels of self-confidence in these specific communication and collaboration skills (see Table 11). For three of the survey items, however, the proportion of respondents who either “agreed/strongly agreed” that they possessed these skills varied by more than five percentage points between upper elementary school students and middle and high school students:

- A greater proportion of upper elementary school students (85.9%) agreed/strongly agreed that they liked to help others do their best, as compared to middle and high school students (79.7%).
- More middle and high schools students (77.5%) agreed/strongly agreed that they thought about what is good for other people when making decisions as compared to upper elementary school students (71.7%).
More middle and high school students (78.0%) agreed/strongly agreed that they can change their actions for the better “when things do not go how [they] want” as compared to upper elementary school students (69.6%).

Table 11

Upper Elementary and Middle and High School Student Confidence in 21st Century Skills by Proportion of “Agree/Strongly Agree”

<table>
<thead>
<tr>
<th>Survey Item</th>
<th>Upper Elementary (n=859)</th>
<th>Middle and High School (n=8,456)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can lead others to reach a goal.</td>
<td>69.0%</td>
<td>73.2%</td>
</tr>
<tr>
<td>I like to help others do their best.</td>
<td>85.9%</td>
<td>79.7%</td>
</tr>
<tr>
<td>I respect all children my age even if they are different from me.</td>
<td>79.9%</td>
<td>84.8%</td>
</tr>
<tr>
<td>I try to help other children my age.</td>
<td>82.7%</td>
<td>81.9%</td>
</tr>
<tr>
<td>When I make decisions, I think about what is good for other people.</td>
<td>71.7%</td>
<td>77.5%</td>
</tr>
<tr>
<td>When things do not go how I want, I can change my actions for the better.</td>
<td>69.6%</td>
<td>78.0%</td>
</tr>
<tr>
<td>I can work well with all students, even if they are different from me.</td>
<td>73.2%</td>
<td>75.6%</td>
</tr>
</tbody>
</table>

Note: The wording of the survey items was taken from the pilot Upper Elementary Student Attitudes toward STEM Survey. The items are written at a slightly higher reading level in the Middle and High School Student Attitudes toward STEM Survey. Responses were recorded on a five-point Likert scale ranging from “strongly disagree” (1) to “strongly agree” (5).

Addressing multiple learning styles. In addition to raising engagement among students, supporting learning that integrates content, and facilitating student collaboration, the new STEM curricula and activities also address the learning styles of a variety of students. The investigative labs, new computerized equipment, and problem-based curricula challenge all students, and they also especially connect with students who learn best from visual and hands-on experiences. Across focus groups, multiple educators discussed the degree to which the hands-on activities in STEM classes connect with these mechanical learners. One teacher reflected:

*I’ve had some of those same students [that are disengaged], and when I sit them in front of the gear trainer, or sit them in front of the pneumatics setup, they will work through those things so quickly. I mean, these are those kids who are just mechanically minded."

Another explained:

*When you start talking about differentiating learning, I think this is so hands-on that it reaches your visual people, it reaches the kinesthetic learners - it uses all these different methods.*
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Problem-solving. An objective of the Golden LEAF STEM Initiative is to increase problem-solving skills in young students; employers often cite those abilities as key qualities they seek in their employees. Problem-solving skills include, among other proficiencies, the ability to make sense of problems, reason abstractly, reason quantitatively, construct viable arguments, use appropriate tools, persevere in problem-solving, and attend to precision. Focus group results suggest that the implementation of grant activities have already begun to increase the problem-solving skills of participating students. One teacher simply stated:

I can see a big improvement on my kids in breaking apart a problem and using different strategies.

Another expressed:

A lot of times I think kids think there’s a box that they have to be in, and now I think they’ve learned what real true experimenting is - the purpose of experimenting and the purpose of really walking through problem-solving issues ... At the beginning of the year they were thinking, “Well I made a mistake. What do I do?” and they’d ask us a question. But now they’re saying, “What if we did it this way or what if we tried it this way?” And a lot of the grade-levels at our school have been saying the exact same thing, that the kids are now not even asking for permission anymore to try something new. They’re just diving in and doing it on their own, which is a great experience for them.

Accelerating student learning overall. Results from focus group conversations suggest that even though standardized tests may not detect any changes in student learning after a year of implementation, teachers were finding that there was an increase in student learning by the other measures described above. The educators also anticipated that more learning outcomes would be realized in years to come. Multiple teachers from all school-levels, elementary, middle, and high, predicted that students participating in the Golden LEAF STEM Initiative would be positioned for advanced learning earlier than students who did not have such opportunities. As one teacher put it:

I can see a large growth, especially in just the students’ ability to take what they’ve learned in science and math and bring it here to this [engineering] class ... they can see that they’re going to need it now. I think that they’re going to be ready for the 9th grade science or the 9th grade math or whatever it is that they’re going into. I can see a big difference.

Another shared:

I’m excited to think that down the road the kids that [teacher] will get or that [teacher] will get, will have this elementary base and it’s just a vertical alignment all the way up. The students will just get better and better. They’ll understand STEM better, understand math better, be better problem solvers, better thinkers. I’m just excited that they’re going to be exposed early on and will just be with it all the way up.
To what degree or in what ways were the Golden LEAF STEM Initiative grantees as a whole effective in changing teachers’ instructional practice?

Teacher characteristics

Goals of the Golden LEAF STEM Initiative also include supporting the continued development of STEM instructional practices among North Carolina educators. In order to understand better the sample of teachers from across the state participating in the initiative, teachers were asked to share information about their background (see Table 12). After cleaning data to remove respondents who indicated that they did not teach courses related to engineering, the sample size for engineering teachers (9) was too small to report. Full results from the teacher surveys, including all respondents to the pilot engineering teacher survey, can be found in Appendices K-O.

Analyses of the demographic characteristics of teacher survey respondents show that females outnumbered males in every teacher survey. There were no Asian, Native Hawaiian/Other Pacific Islander, or Hispanic/Latino teachers in the sample and few Black/African American teachers. Of those participating teachers who hold National Board Certification, the largest proportion was among the elementary teachers (24.4%) and the smallest proportion among the technology teachers (14.8%).

Table 12
Teacher Demographic Characteristics and National Board Certification

<table>
<thead>
<tr>
<th>Demographic Characteristic</th>
<th>Percentage of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Science (n=155)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>22.6%</td>
</tr>
<tr>
<td>Female</td>
<td>77.4%</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td></td>
</tr>
<tr>
<td>American Indian/Alaska Native</td>
<td>1.9%</td>
</tr>
<tr>
<td>Asian</td>
<td>0.0%</td>
</tr>
<tr>
<td>Black/African American</td>
<td>4.5%</td>
</tr>
<tr>
<td>Native Hawaiian/Other Pacific Islander</td>
<td>0.0%</td>
</tr>
<tr>
<td>White/Caucasian</td>
<td>90.3%</td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>0.0%</td>
</tr>
<tr>
<td>Multiracial</td>
<td>1.3%</td>
</tr>
<tr>
<td>National Board Certification</td>
<td>17.4%</td>
</tr>
</tbody>
</table>
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Data collected on the participating teachers’ years of teaching experience show that, on average, teachers participating in the Golden LEAF STEM Initiative have 12.9 years of experience (Table 13). Teachers responding to the pilot Technology Teacher Attitudes toward STEM Survey had the lowest average years of teaching experience (8.0).

Table 13  
Teacher Average Years of Experience

<table>
<thead>
<tr>
<th></th>
<th>Science (n=156)</th>
<th>Technology (n=27)</th>
<th>Math (n=94)</th>
<th>Elementary (n=168)</th>
<th>TOTAL (n=445)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Years of Experience</td>
<td>14.3</td>
<td>8.0</td>
<td>15.0</td>
<td>14.1</td>
<td>12.9</td>
</tr>
</tbody>
</table>

Teacher Outcomes

The Golden LEAF STEM Initiative aims to provide support for the continued development of instructional skills among participating teachers. High-quality instruction is made up many components, including the application of inquiry-based teaching strategies. These strategies give students opportunities to discover concepts on their own. Exemplary teaching also provides opportunities for students to hypothesize, experiment, analyze, reason, and engage in other elements of problem-solving, and achieves the delivery of content that is challenging to the learner. If resources are available, good instruction also makes use of instructional technology.

Defining STEM. There is a lot of national-level discussion taking place about the specific definition of “STEM education.” The Golden LEAF STEM Initiative evaluation focus group protocol asked teachers to share their own understanding of STEM education. Most of the teachers participating in focus groups shared a similar, broad understanding of STEM education which also matched well with the concept that the Golden LEAF STEM Initiative has taken-on. When asked, “What do you all think of when you hear the term ‘STEM education,’” the educators most frequently listed the following items:

- Teaching and learning in science, technology, engineering, and mathematics;
- Integrating the STEM subjects;
- Preparing students for the types of jobs that are available in today’s labor market;
- Preparing students for the unknown jobs of the future; and
- Teaching students problem-solving skills.

An activity that took place during the annual Summer STEM Evaluation Institute (see Section III) asked grant leadership teams to discuss what their STEM program has meant to their school or district. Similar themes emerged from that conversation as well. Appendix I contains images of “word clouds” that capture the words that came up most frequently in each discussion.

Curricula that support inquiry-based teaching. Focus group results suggest that the curricula, kits, and other instructional materials provided by the Golden LEAF STEM Initiative grant activities increased the frequency with which teachers used inquiry-based teaching strategies.
Multiple teachers talked about how they had begun changing their instructional practice in all their classes. One educator explained:

*I kind of think it’s changed my mindset when I start a lesson now. I don’t usually start it with, “This is what you are going to do.” I start it with a question instead of an answer and then their job is to find the answer ... So the labs affect how you teach other kinds of things too.*

The same teacher explained how the particular materials were supporting teachers with varying skill-sets:

*Some teachers who have felt scared in the past to try these types of investigations, it does give them support. It’s very step-by-step and has been laid out. If they don’t feel comfortable, they have something they can rely on ... It does give even those teachers who didn’t feel comfortable to begin with, it gives them a little different mindset.*

Another teacher described their experience using a new, inquiry-based curriculum:

*It’s difficult to come up with a hands-on lesson that is concrete, and that also moves toward all the abstract concepts, but [that] is all in the lessons that they provide, so that that has helped me.*

**Professional development.** Professional development opportunities are a key support structure for teachers and an important tool for continuously improving instructional practice. The focus group protocol asked the participating STEM teachers to think about the professional development they have received in general, instead of only the activities sponsored by the Golden LEAF STEM Initiative. The protocol asked teachers to reflect on the aspects of professional development that they found most helpful and also least helpful. Several STEM teachers reported that they benefited greatly from professional development which allowed them to engage in hands-on learning themselves. Explicating further, a couple teachers described the usefulness of professional development sessions that allowed them to take on the role of students and conduct investigative labs, labs that they would later lead in their classroom. Other participating educators commented that they learned the most from facilitators that modeled the style of instruction being presented. Reflecting on a grant-provided event, a teacher described:

*The facilitators were good about letting us figure it out on our own. They wouldn’t give us the answer - whatever they gave us was all that we got. If you asked them a question, they would just smile. It was great for us and it also helped us realize, “Okay, this is what we’re going to have to do with the students.”*

Additionally, the educators described learning a lot when professional development activities provided opportunities to observe STEM professionals in their work environments. This type of experience provides STEM teachers with critical information about the nature of today’s research and industry, which they are then able to share with students. Data collected from the administration of the pilot Golden LEAF STEM Program Implementation Rubric indicated that a majority of grant leadership teams (10 out of 13) estimated that within their program and
participating schools either very few or up to 25% of STEM educators participate in at least one applied learning experience with STEM industry professionals (Attribute B1). This lack of opportunities to engage with research and industry is likely due, in part, to a variety of current institutional and organizational barriers. A few Golden LEAF STEM Initiative grants were able to include these types of learning opportunities in their program strategies. Remembering a tour of regional STEM industries, one teacher reflected:

> What was most beneficial to me was seeing what people go into if they go to two-year colleges after they get out of school. We went and looked at how car manufacturers use the technology and saw the same at a satellite dish company. We saw different things in this area that students could use their skills for to find jobs after a two-year degree. It gave us a different outlook from what we normally see as teachers.

During focus group discussions participating teachers described other types of professional development activities that have been helpful. The educators said that they would like to have more opportunities to participate in professional development that provides:

- Information about specific instructional technology tools;
- Content-area material, such as introductions to advanced topics for mathematics teachers or reviews of the latest biological research for biology teachers;
- Information that is specific to a teacher’s individual needs, as opposed to large group sessions on basic skills; and
- Opportunities for learning that bring together teachers from across content areas and/or grade-levels.

Implementation rubric results indicate that opportunities for individualized professional development experiences that are specific to teachers’ needs are infrequent: 11 out of 14 grant leadership teams who completed that item on the rubric estimated that their program, school(s), and/or district(s) are “early or developing” in this component of professional development (Attribute A5). Typically more standardized, large-group experiences are provided.

Finally, some participating teachers were frustrated more generally at the frequency with which they had been asked to learn a new skill, curriculum, tool, or teaching strategy for any purpose or initiative. Sometimes referred to as “implementation fatigue,” this theme was found across multiple focus groups. One teacher described:

> I don’t want another program. If we’re going to get some money, then let’s have some money to make the programs that we have work better. I don’t want anything else. What I have right now is enough. Give me some time. Give me somebody who’s going to sit down and help us break [the curriculum] apart. Give us even just one day to be able to do that.

**Collaboration.** The opportunity for meaningful collaboration among teachers is another important working condition which leads to growth in instructional skills of teachers (Jackson & Brueggman, 2009). In a few focus groups teachers described the culture for teamwork at their school:

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We work really well together, and we share lessons. We may not sit down on a daily basis, but we all kind of know what’s going on and if we make something, we share it, or we go get a flash drive … If you have good teammates, which I do, it makes a total, world of difference.

Multiple teachers across focus groups indicated that additional time for collaboration would help them improve their instructional practice. Several teachers recommended that increasing the amount of shared planning time across teachers of different subjects would increase their ability to integrate content. Shared experiences, like trips to conferences or extended trainings with a team of colleagues, can double as meaningful collaboration time. Finally, educators from two grants stressed the importance of not only providing increased time for teamwork, but also abstaining from micromanaging that time. These teachers suggested that instead administrators should let the teachers decide what activities would be most useful for them to undertake together.

Technology. While a few teachers admitted their skepticism that personal computers and handheld devices have the potential to transform dramatically teaching and learning, the vast majority of the teachers in focus groups clearly stated that such tools increase student engagement and facilitate meaningful learning opportunities. Several focus group conversations highlighted the power that technology tools have to engage today’s students. Most young people live in a world surrounded by televisions, smart phones, and personal computers and easily become disengaged when they enter classrooms that do not resemble their everyday life. In speaking about technology in the classroom, one educator reflected:

[Technology] is very helpful just to grab their attention, which in the age we live in, seems very important. You need to be able to grab their attention right at the beginning.

In a different focus group another teacher described:

There are no behavior problems when their laptops are up. They’ll all be working on something different, but they’re all engaged and they’re all working.

Instructional technology tools also provide unique opportunities for interactive learning in the classroom. For example, on-demand access to online resources and research opportunities facilitates content integration and connections to real-world applications. One teacher explained it well:

These are teaching tools that allows us to bring outside, real-life applications into the classroom. It allows tactile learning, like students doing more hands-on, and being more involved, having more of an experience than just sitting down and absorbing information - actually having an experience.

Even though most school district faculty and staff recognize the ability of technology tools to provide high quality learning experiences for students and critical support for teachers, results from the focus groups show a consistent lack of access to instructional technology resources.
Many participating teachers described their schools as having so few class-sets of computers that it has been difficult for teachers to use them in meaningful ways. They described losing significant amounts of valuable instructional time in the planning and coordination process, or being unable to access computers when unplanned learning opportunities arise.

Additionally, the educators explained that STEM-specific subjects require other types of technology tools in order to deliver the results demanded by today’s postsecondary training and employers. Many teachers across Golden LEAF STEM Initiative grants illustrated the difficult situation; one said:

> We’re trying to teach our students in a twenty-first century way with mid-nineteenth century technology. And it’s not just the computers ... I’d love for them to have the kind of 3D modeling software to design their product right there and build it right there in the same spot ... It’s not engineering if you can’t apply it.

In another focus group a participant stated:

> My primary issue is having a variety of materials for the kids to work with. Right now I average spending about $200 a month in materials out of my pocket for opportunities for the kids to do things better than what’s here ... If you don’t have the materials, it’s all theoretical again.

Their colleague agreed:

> I’m going to second that, with the supplies. I mean, our basic equipment is pitiful. If I wanted to do a solar voltaic activity, I might be able to come up with one set of solar panel batteries. Basic calculators die and we don’t have a source of batteries. We have to either buy them ourselves or something else goes along the way.

School schedules. Another critical support for high quality instructional practice is the provision of appropriate blocks of time for teaching and learning. With regard to STEM subjects, school districts typically provide the most class time and course options in math education and the least in engineering and other technical subjects. Class time and course options for science falls somewhere in the middle for most districts, but was cut almost completely out of elementary curriculum for during much of the No Child Left Behind era (Griffith & Scharmann, 2008; Marx & Harris, 2006). A few elementary and middle school teachers reported that they had difficulty delivering the most effective science instruction to their students because they have very short class periods (e.g. 30 minutes) or infrequent class periods (e.g. approximately half the frequency of other subjects). Overall, throughout almost every focus group with teachers from varying school-levels, educators described how short class periods (often of about 50 minutes or less) constrain their ability to provide deep, meaningful, inquiry-based learning experiences for students. In one discussion a teacher shared:

> We feel time constraints because of how long a subject’s class is supposed to last. Or we feel time constraints because “I’ve got to move on because we’re supposed to be [at this place in the curriculum] by tomorrow.” But when you slow down and you let the students
An educator participating in a different Golden LEAF STEM Initiative grant said:

“We did DNA extraction and we had them do it with their own cheek cells. But we had to rush through it and get it done in one day, so there was no time to talk about it and really absorb the material ... That’s how it is all year and that’s what’s taking all the fun out of it. That’s why students don’t like science.

Teachers in two districts reported that their school or district was making plans to increase the amount of time for science in the daily schedule, and one district had plans to add some flexibility into the elementary school schedule so that longer class periods were occasionally available.

Teachers’ confidence and outcome expectancy. Baseline findings from the pilot Science, Technology, Engineering, Math, and Elementary Teacher Attitudes toward STEM Surveys show that, when asked about aspects of their instructional practice, educators participating in the Golden LEAF STEM Initiative had a pretty strong sense of confidence and self-efficacy overall (3.9 scale-level mean composite score on PSTEBS; see Table 14). Results also show that the teachers had mildly positive expectations that these efforts in the classroom can significantly impact student achievement (3.4 scale-level mean composite score on STOES). Furthermore survey results indicate that the teachers’ sense of self-efficacy and the degree to which they expect their actions in the classroom to impact student learning did not vary within the types of STEM teachers (science, technology, math, and elementary). Full results from the survey administration can be found in Appendices K-O.

Table 14
Mean Composite Scores of Teacher Self-efficacy and Beliefs (PSTEBS) and Outcome Expectancy (STOES)

<table>
<thead>
<tr>
<th>Scale</th>
<th>Science</th>
<th>Technology</th>
<th>Math</th>
<th>Elementary</th>
<th>All Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>156</td>
<td>27</td>
<td>94</td>
<td>168</td>
<td>445</td>
</tr>
<tr>
<td>Personal (STEM) Teaching Efficacy and Beliefs Scale (PSTEBS)</td>
<td>4.0</td>
<td>4.1</td>
<td>4.1</td>
<td>3.8</td>
<td>3.9</td>
</tr>
<tr>
<td>(STEM) Teaching Outcome Expectancy Scale (STOES)</td>
<td>3.4</td>
<td>3.4</td>
<td>3.4</td>
<td>3.5</td>
<td>3.4</td>
</tr>
</tbody>
</table>

Note: Responses were recorded on a five-point Likert scale: “strongly disagree” (1), “disagree” (2), “neither agree nor disagree” (3), “agree” (4), and “strongly agree” (5). The sample size for technology teachers is low, therefore these results should be interpreted with caution.
Survey results are the most powerful and reliable when they are considered at the scale-level, or when a respondent’s answers to multiple, similar questions are synthesized as a single finding. At the same time, examining individual survey-item results can reveal some interesting patterns and identify possible areas for further investigation. The item-level data on teachers’ confidence and self-efficacy reveal that technology teachers’ levels of confidence most frequently differed by more than five percentage points from the average (Table 15). The technology teachers were sometimes more confident and sometimes less confident than others as a whole. Some of this variation in the technology teachers’ results could, however, be due to their low sample size.

Table 15
Teacher Self-efficacy and Beliefs (PSTEBs) by Proportion of “Agree/Strongly Agree”

<table>
<thead>
<tr>
<th>Personal (STEM) Teaching Efficacy Beliefs Scale (PSTEBs)</th>
<th>Science</th>
<th>Technology</th>
<th>Math</th>
<th>Elementary</th>
<th>All Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>156</td>
<td>27</td>
<td>94</td>
<td>168</td>
<td>445</td>
</tr>
<tr>
<td>I am continually finding better ways to teach (STEM subject).</td>
<td>95.6%</td>
<td>92.5%</td>
<td>96.8%</td>
<td><strong>84.5%</strong></td>
<td>90.6%</td>
</tr>
<tr>
<td>I know the steps necessary to teach (STEM subject) concepts effectively.</td>
<td>89.1%</td>
<td>96.3%</td>
<td>95.8%</td>
<td>81.3%</td>
<td>85.1%</td>
</tr>
<tr>
<td>I am not confident that I can monitor (STEM subject) activities well.</td>
<td>23.3%</td>
<td><strong>11.1%</strong></td>
<td>20.2%</td>
<td>18.3%</td>
<td>19.3%</td>
</tr>
<tr>
<td>I am not confident that I can teach (STEM subject) effectively.</td>
<td>7.7%</td>
<td>7.4%</td>
<td>12.8%</td>
<td>12.6%</td>
<td>10.2%</td>
</tr>
<tr>
<td>I understand (STEM subject) concepts well enough to be effective in teaching (STEM subject).</td>
<td>88.5%</td>
<td><strong>96.2%</strong></td>
<td>86.2%</td>
<td>83.9%</td>
<td>84.9%</td>
</tr>
<tr>
<td>I am not confident that I can explain to students how (STEM subject) works.</td>
<td>11.5%</td>
<td><strong>18.5%</strong></td>
<td>8.6%</td>
<td>14.2%</td>
<td>11.8%</td>
</tr>
<tr>
<td>I am confident that I can answer students’ (STEM subject) questions.</td>
<td><strong>85.9%</strong></td>
<td><strong>88.9%</strong></td>
<td><strong>88.2%</strong></td>
<td>78.5%</td>
<td>80.7%</td>
</tr>
<tr>
<td>I wonder if I have the necessary skills to teach (STEM subject).</td>
<td>7.0%</td>
<td><strong>18.6%</strong></td>
<td><strong>2.2%</strong></td>
<td>12.0%</td>
<td>7.6%</td>
</tr>
<tr>
<td>Given a choice, I would not invite the principal to evaluate my (STEM subject) teaching.</td>
<td>17.9%</td>
<td><strong>22.2%</strong></td>
<td>10.7%</td>
<td>14.4%</td>
<td>14.8%</td>
</tr>
<tr>
<td>When a student has difficulty understanding at (STEM subject) concept, I am not confident that I know how to help the student understand it better.</td>
<td>10.2%</td>
<td>7.4%</td>
<td>7.5%</td>
<td><strong>9.2%</strong></td>
<td><strong>8.8%</strong></td>
</tr>
<tr>
<td>When teaching (STEM subject), I am confident enough to welcome student questions.</td>
<td><strong>88.5%</strong></td>
<td><strong>92.6%</strong></td>
<td><strong>88.2%</strong></td>
<td>85.1%</td>
<td><strong>84.2%</strong></td>
</tr>
<tr>
<td>I don’t know what to do to turn students on to (STEM subject).</td>
<td>5.8%</td>
<td>3.7%</td>
<td>6.5%</td>
<td>7.3%</td>
<td>6.1%</td>
</tr>
</tbody>
</table>
Item-level results from the STOES scale show that participating teachers had just slightly positive expectations that educators in general can impact student learning (Table 16). Results from a question that asked teachers how much they agreed with the statement: “The teacher is generally responsible for the achievement of students in (STEM subject),” show that one out of two teachers agreed or strongly agreed with the assertion. Similarly, just over half (53.5%) of teachers reported that they agreed or strongly agreed that: “Students' achievement in (STEM subject) is directly related to their teacher's effectiveness in (STEM subject) teaching.” Despite these mixed results, in which about half of teachers do not agree or strongly agree with teachers’ abilities to impact students, there does seem to be an overall sense among teachers that at least some level or amount of teacher-impact on students is possible. Very few STEM teachers (8.1%), for example, agreed or strongly agreed that increased effort by a teacher will produce only a little change in student achievement. Also only 5.0% of teachers agreed or strongly agreed that “even teachers with good (STEM subject) teaching abilities cannot help students learn.”

Interestingly, item-level data reveal that in regards to their levels of outcome expectancy (STOES), the science, technology, math, and elementary teachers varied around the average more than they did in their confidence and self-efficacy (PSTEBS). Twenty-three out of 48 proportions calculated on the science, technology, math, and elementary teachers’ item-level STOES responses differed from the average by more than five percentage points. The greatest difference (15.9 percentage points) is in the responses to the item: “The teacher is generally responsible for the achievement of students in (STEM subject).” For this question, 56.6% of elementary teachers agreed or strongly agreed while only 40.7% of technology teachers did. In contrast, the greatest consensus among teachers came from responses to the question: “Even teachers with good (STEM subject) teaching abilities cannot help students learn (STEM subject).” For this item 7.6% of math teachers agreed or strongly agreed while only 2.8% of elementary teachers did.

Table 16
Teacher Outcome Expectancy (STOES) by Proportion of “Agree/Strongly Agree”

<table>
<thead>
<tr>
<th>STEM Teaching Outcome Expectancy Scale (STOES)</th>
<th>Science</th>
<th>Technology</th>
<th>Math</th>
<th>Elementary</th>
<th>All Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>When a student does better than usual in (STEM subject), it is often because the teacher exerted a little extra effort.</td>
<td>51.3%</td>
<td>48.1%</td>
<td>49.0%</td>
<td>59.4%</td>
<td>53.3%</td>
</tr>
</tbody>
</table>
**Golden LEAF STEM Initiative**
August 2012

<table>
<thead>
<tr>
<th><strong>STEM Teaching Outcome Expectancy Scale (STOES)</strong></th>
<th>Science</th>
<th>Technology</th>
<th>Math</th>
<th>Elementary</th>
<th>All Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>When the (STEM subject) grades of students improve, it is most often due to their teacher having found a more effective teaching approach.</td>
<td>67.3%</td>
<td>62.9%</td>
<td>63.9%</td>
<td><strong>76.1%</strong></td>
<td>67.3%</td>
</tr>
<tr>
<td>If students are underachieving in (STEM subject), it is most likely due to ineffective (STEM subject) teaching.</td>
<td><strong>14.8%</strong></td>
<td>22.2%</td>
<td><strong>14.9%</strong></td>
<td><strong>28.9%</strong></td>
<td>20.0%</td>
</tr>
<tr>
<td>The inadequacy of a student's (STEM subject) background can be overcome by good teaching.</td>
<td>63.5%</td>
<td><strong>85.2%</strong></td>
<td>59.5%</td>
<td><strong>70.6%</strong></td>
<td>64.5%</td>
</tr>
<tr>
<td>The low (STEM subject) achievement of students cannot generally be blamed on their teachers.</td>
<td><strong>38.5%</strong></td>
<td><strong>48.1%</strong></td>
<td>35.1%</td>
<td><strong>25.7%</strong></td>
<td>32.5%</td>
</tr>
<tr>
<td>When a low achieving child progresses in (STEM subject), it is usually due to extra attention given by the teacher.</td>
<td>56.4%</td>
<td><strong>70.4%</strong></td>
<td>60.7%</td>
<td><strong>64.7%</strong></td>
<td>58.3%</td>
</tr>
<tr>
<td>Increased effort in (STEM subject) teaching produces little change in students' (STEM subject) achievement.</td>
<td>10.9%</td>
<td><strong>0.0%</strong></td>
<td>11.7%</td>
<td>5.6%</td>
<td>8.1%</td>
</tr>
<tr>
<td>The teacher is generally responsible for the achievement of students in (STEM subject).</td>
<td>46.2%</td>
<td><strong>40.7%</strong></td>
<td>54.2%</td>
<td><strong>56.6%</strong></td>
<td>49.8%</td>
</tr>
<tr>
<td>Students' achievement in (STEM subject) is directly related to their teacher's effectiveness in (STEM subject) teaching.</td>
<td><strong>47.5%</strong></td>
<td><strong>59.2%</strong></td>
<td><strong>61.3%</strong></td>
<td><strong>59.0%</strong></td>
<td><strong>53.5%</strong></td>
</tr>
<tr>
<td>If parents comment that their child is showing more interest in (STEM subject) at school, it is probably due to the performance of the child's teacher.</td>
<td><strong>63.4%</strong></td>
<td>55.5%</td>
<td><strong>64.6%</strong></td>
<td>55.0%</td>
<td><strong>57.9%</strong></td>
</tr>
<tr>
<td>Effective (STEM subject) teaching has little influence on the achievement of students with low motivation.</td>
<td>14.8%</td>
<td>18.5%</td>
<td><strong>21.5%</strong></td>
<td>9.0%</td>
<td><strong>13.8%</strong></td>
</tr>
<tr>
<td>Even teachers with good (STEM subject) teaching abilities cannot help students learn (STEM subject).</td>
<td>7.0%</td>
<td>3.7%</td>
<td>7.6%</td>
<td>2.8%</td>
<td>5.0%</td>
</tr>
</tbody>
</table>

*Note:* Responses were recorded on a five-point Likert scale ranging from “strongly disagree” (1) to “strongly agree” (5). Bold proportions highlight those that are more than five percentage points greater or lesser than the average proportion for all teachers. The sample size for technology teachers is low, therefore these results should be interpreted with caution.

In general, both the participating teachers’ sense of self-efficacy and their expectations for the degree to which any educators’ efforts can impact student learning do not vary when the teachers...
are sorted by personal characteristics. Independent comparisons show that male teachers and female teachers had similar levels of confidence and outcome expectancy, as did teachers with and without National Board Certification, teachers with varying years of experience, teachers instructing in elementary, middle or high school, and teachers instructing in mathematics, science, or technology. See Appendix O for complete results.

Within the mathematics and science teachers there was some variation in the confidence of teachers by school-level: elementary teachers had lower levels of confidence in aspects of their mathematics and science instructional practice than their middle and high school colleagues (Table 17).

Table 17
Science and Math Teacher Self-efficacy and Beliefs (PSTEBS) by School Level

<table>
<thead>
<tr>
<th>School Level</th>
<th>Mean Composite Score PSTEBS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Science Teachers</strong></td>
<td></td>
</tr>
<tr>
<td>Elementary (n=162)</td>
<td>3.8</td>
</tr>
<tr>
<td>Middle (n=127)</td>
<td>3.9</td>
</tr>
<tr>
<td>High (n=22)</td>
<td>4.2</td>
</tr>
<tr>
<td><strong>Math Teachers</strong></td>
<td></td>
</tr>
<tr>
<td>Elementary (n=157)</td>
<td>3.5</td>
</tr>
<tr>
<td>Middle (n=71)</td>
<td>4.1</td>
</tr>
<tr>
<td>High (n=18)</td>
<td>4.0</td>
</tr>
</tbody>
</table>

*Note: Responses were recorded on a five-point Likert scale: “strongly disagree” (1), “disagree” (2), “neither agree nor disagree” (3), “agree” (4), and “strongly agree” (5). Sample sizes for high school teachers are low, therefore these results should be interpreted with caution.*

**Instructional support for STEM learning.** In visiting classrooms evaluation team members completed 58 CLASS observation protocols. Each captures a 15-minute period of instruction, using a seven-point numeric scale across multiple dimensions. They were completed within 29 total hours of observed instructional time in 22 participating classrooms across the initiative. Results indicate that a majority of teachers participating in the Golden LEAF STEM Initiative either somewhat frequently or very frequently engaged in a number of activities of high-quality instructional support for STEM learning (Table 18). Evaluation team members most often saw activities supporting communication and transmission of content knowledge (82.8% of protocols scored at 3 or higher) and opportunities for students to engage in analysis and problem-solving (72.4% of protocols scored at 3 or higher). During 62.1% of the time that evaluation team members visited classrooms there were regular, one-on-one exchanges between students and teachers. Slightly less frequently observed were extended, content-driven exchanges among a majority of the students in a class (55.2% of protocols scored at 3 or higher).

There was some variation among teachers of different racial/ethnic groups, however due to very low sample sizes of these groups, results were not considered reliable.
It should be noted that, due to the timing of certain site visits, a few classroom visits were made during a time when an activity or lesson specifically supported by the Golden LEAF STEM Initiative was not being implemented. Instead other science, technology, engineering, or math lessons were taking place.

Table 18
*Instructional Support by Percentage of CLASS Protocol Dimensions Scored at a 3 or Greater*

<table>
<thead>
<tr>
<th>Instructional Support Dimension</th>
<th>All Protocols (n=58)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitting Content Knowledge</td>
<td>82.8%</td>
</tr>
<tr>
<td>Providing Opportunities for Analysis and Problem-Solving</td>
<td>72.4%</td>
</tr>
<tr>
<td>Providing Positive, One-on-One, Verbal Feedback</td>
<td>62.1%</td>
</tr>
<tr>
<td>Facilitating Content-Driven, Student-Led Dialogue</td>
<td>55.2%</td>
</tr>
</tbody>
</table>

*Note:* The official names for the dimensions used in CLASS are slightly abbreviated from what is shown in the table; these changes were made to support readers unfamiliar with the protocol. The CLASS protocol uses a seven-point frequency rating scale, ranging from 1 to 7. All evaluation team members have received training and are certified users of the protocol. For more information about CLASS™, see: [http://www.teachstone.org/about-the-class](http://www.teachstone.org/about-the-class).

**III. Capacity-Building Activities**

The second, main objective of the Golden LEAF STEM Initiative evaluation is to provide technical assistance to increase the capacity of schools and districts for collecting and using a variety of data for decision-making. Each grantee, as part of their agreement with the Golden LEAF Foundation, is required to take part in these capacity-building evaluation activities. As recent school improvement research has demonstrated, “[c]apacity problems are too often the barrier rather than the core focus of many reform efforts” (Roderick, Easton, & Sebring, 2009, p. 16). Other research finds that consistent and formal data-informed policies can lead to improvements in education programs overall (Bryk, Gomez, & Grunow, 2011) and also specifically students’ math achievement (Carlson, Borman, & Robinson, 2011; Marsh, Pane, & Hamilton, 2006).

More specifically, the evaluation team focuses on achieving two main goals: supporting each of the grantees to (1) develop and apply knowledge about education program evaluation; and (2) collect, interpret, and use formative data to improve their STEM programs. The goals are for grantees to experience using traditional and new types of STEM education data for continuous improvement, to explore what types of data are of optimal use, and to use the findings to design and improve programs. The technical assistance also aims to provide grantees with a framework and some common instruments with which to make these decisions, increasing program coherence across the entire initiative (Bryk et al., 2011; Honig & Hatch, 2004; Newmann et al., 2001).
Golden LEAF STEM Initiative
August 2012

In order to accomplish these goals the evaluation team has carried-out several activities thus far. The team has: hosted annual face-to-face institutes; held semi-annual webinars; created initiative-level and grantee-level survey results reports; provided one-on-one reference support; built the foundation for a Golden LEAF STEM Initiative evaluation online community of practice; and engaged national and state education leaders in discussions about the on-going evaluation and capacity-building work for the Golden LEAF STEM Initiative. Capacity-building activities that have taken place since the writing of the most recent Golden LEAF STEM Initiative baseline report in March 2012 are described below.

Initiative- and Grantee-level Survey Results Reports

The pilot Science, Technology, Engineering, Mathematics, and Elementary Teacher Attitudes toward STEM Surveys and pilot Upper Elementary and Middle and High School Student Attitudes toward STEM Surveys serve a dual purpose for the Golden LEAF STEM Evaluation. First, these surveys support the initiative-level evaluation which seeks to understand the overall impacts of the 14 grants on participating teachers and students (see Section II). The second role that these surveys play is to support continuous improvement efforts of individual grantees. The evaluation team has crafted the surveys so that the results can be compiled at both the initiative-level and also at the grant-level.

After the December 2011 – February 2012 initiative-wide administration of the student and teacher surveys, the evaluation team provided surveys results back to the grant leaders in two stages. The first stage consisted of providing two initiative-level results reports in April 2012: one report contained the aggregated results (from across all 14 grants) of the upper elementary and middle and high school student surveys, and the other contained the aggregated results from the five teacher attitudes toward STEM surveys. These reports also contained demographic data describing the total sample of respondents. In June 2012 the evaluation team completed the second stage of sharing survey results back with grantees, and provided each grantee with their own set of results reports. These reports contained data from each grant’s participating teachers and students. The reports were in the same format as the initiative-level reports without the demographic data; this was done in order to protect the anonymity of the students and teachers who took the surveys. Grant leadership teams were encouraged to reflect on their survey results, determine if and how the results could be useful, and then to use the data to inform their future decisions about program design. Grant coordinators were also encouraged to consider using these reports to reflect on potentially new data collection strategies in the coming year. The leadership teams brought their grant-level survey results reports to the summer institutes for use in additional capacity-building activities and during the dedicated team planning time.

Spring 2012 Webinar

The fourth in a series of semi-annual evaluation capacity-building webinars was held on April 19, 2012. These webinars provide opportunities for the evaluation team to connect with the grant coordinators and to share information on different topics related to formative evaluation. Morning and afternoon sessions were held in order to provide the most flexibility for the schedules of grant leaders. The April 19 webinar topic addressed strategies for collecting and
analyzing data (see Appendix P for the webinar agenda). The initiative-level survey results reports created by the evaluation team were used as examples and points of discussion. Attendance included 17 grant leaders from across 10 of the 14 grants.

Summer STEM Evaluation Institute 2012

The annual, face-to-face summer institute series provides opportunities for the evaluation team and grantees/leadership teams to discuss the initiative work, share information, and interact over the course of an entire day. Each summer institute is held twice, once in Raleigh and once in Asheville, in order to reduce the travel burden on grantee teams.

The second annual Summer STEM Evaluation Institute was held on two days in July 2012. A survey sent out to grant leaders in the spring asked them to rank five, proposed activities and to offer other suggestions for the institute agenda. Fifteen responses were collected and the final summer STEM institute agenda addressed two of the grant leaders’ top three recommendations: to spend time networking with each other and to spend time developing their data collection plans for next year. See Appendix Q for the final institute agenda. The institute consisted of three, primary activities:

- The Golden LEAF STEM Initiative grantees networked with each other during roundtable discussions on topics taken from the March 2012 baseline report’s formative findings—they discussed successes and challenges and plans for the future;
- The evaluation team shared tools and strategies for the grantees to consider as they develop their plans to continuously monitor and adjust their programs; and
- The grantee leadership teams used time together for planning their second year of implementation and organizing a data collection strategy.

The roundtable topics consisted of the following:

- **Curriculum, instruction, and pedagogy:** Supporting inquiry-based teaching and learning and formative, classroom-based assessments;
- **School schedules, resources, and technology:** Budgeting and school schedules;
- **Professional learning and collaboration:**
- **School and district leadership:** Connecting with local education stakeholders;
- **Stakeholder engagement:** Connecting with STEM industries and community partners; and
- **Formative evaluation:** Efficiently collecting useful data.  

At the conclusion of the Asheville institute grantees brainstormed a list of outcomes that the Golden LEAF STEM Initiative is aiming to achieve. This list was posted to the Golden LEAF STEM Initiative evaluation wiki (see below) and will be used in the future by both the evaluation team and individual grants to continue to focus and align the work.

15 Only four roundtable topics were facilitated at the Asheville Institute since the participant number was smaller. The “formative evaluation” topic was left out and “school and district leadership” was combined with “stakeholder engagement” as a single topic.
The Golden LEAF STEM Initiative Online Community of Practice

The evaluation team has completed initial activities for building an online community of practice (OCoP) among the Golden LEAF STEM Initiative grantees. The increasing importance of OCoPs for educators is emphasized in the United States’ 2010 National Education Technology Plan (U.S. Department of Education, 2010) which calls for the use of social networking technologies and platforms “to create communities of practice that provide career-long personal learning opportunities for educators within and across schools, pre-service preparation and in-service education institutions, and professional organizations” (p. xviii). Successful OCoPs for educators use networking technologies to increase communication, collaboration, and support among a variety of professionals, including teachers, administrators, and researchers, and enable their members to gain equitable and easy access to resources and materials to enhance their professional practice (Wenger, McDermott & Snyder, 2002).

In the summer of 2011, the Golden LEAF STEM Initiative evaluation team began laying the groundwork for an online community among the initiative grantees by setting-up wiki, a website whose users can add, modify, or delete content with simple editing tools. The web page was created using a popular and free service provided by Wikispaces.com. The Golden LEAF STEM Initiative evaluation wiki is password protected and private so that only users given permission by the evaluation team may view or edit the page and its content. All 2011 and 2012 Summer STEM Institute participants used their Wikispaces.com accounts or opened new, free accounts to join the private web page. The evaluation team uses the wiki to share information about each of the grant projects, archive materials from institutes and webinars, house STEM education resources, and manage evaluation activities, including administrations of the rubric and surveys. A discussion about the quality of the wiki and its potential use as tool for building a Golden LEAF STEM Initiative OCoP was removed from the 2012 summer institute agenda but remains an action item for Year 2. The wiki is available at http://glfstem.wikispaces.com/.

IV. Recommendations

The data collected for this report demonstrate that the Golden LEAF STEM Initiative has produced successful overall results during the first year. The initiative, consisting of the individual work of the 14 grants from across North Carolina, has made progress toward achieving its goals. Findings suggest that as a result of initiative activities student engagement, student learning, and the knowledge and skills of participating STEM teachers have all increased. With two years remaining for project implementation, the initiative has potential to produce more positive results and accomplishments into the future. Findings from the data collected for this report point to some activities which the grantees should continue to prioritize and others which grantees might consider adding to their implementation plans.

Continue to implement hands-on, problem-based STEM curricula and activities; increase emphasis on rigor.

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Results from the focus groups indicate that the hands-on, problem-based STEM curricula, investigative labs, kits, and other activities implemented by the initiative grantees are having significant, positive impacts on levels of student engagement. The activities are also having success meeting the needs of students with varying learning styles. Results from the data collected for this report clearly show that students were gaining important problem-solving skills as a direct result of the inquiry-based STEM activities and other curricular materials. Using the curricula has helped teachers develop their inquiry-based teaching skills as well.

Moving forward, Golden LEAF STEM Initiative grants should to continue to support teachers to use these kinds of materials – both those that the grants implemented in Year 1 and new materials. In order to increase the impact of this successful activity, grants could begin to plan for how participating teachers could take on limited leadership roles and spread their expertise to colleagues.

At the same time, findings from the pilot students attitudes toward STEM surveys indicate that students had moderate levels of confidence and interest in these subjects overall. In the future, grants could increase the focus given to supporting the provision of rigor when using these activities in the classroom. Paying special attention to supporting students to develop the understanding of content that is complex, ambiguous, and provocative may encourage these students to feel more confident in their STEM knowledge and skills. Also notable from the survey findings is that upper elementary school students had more positive attitudes toward STEM subjects than middle school and high school students. Giving priority to STEM education programs at the elementary level may produce the greatest long-term returns.

*Continue to raise student awareness of STEM careers and increase the frequency of opportunities for students to engage with STEM industries through intentional strategies that further relationships between schools and industry.*

Survey results show that students had moderate levels of interest in STEM careers overall. While a few grants provided opportunities for students to engage with STEM industry professionals, a majority of grants did not and focused their resources on other activities. Participating teachers from across multiple grants, without being asked specifically about this issue, indicated that interactions with STEM industries would be beneficial for students and recommended that their school or district provide more of these activities. A couple teachers emphasized that the industry-related activities that have the most impact on students are those that provide interactive opportunities for students, as opposed to poster sessions or speakers. Project leaders should consider the possibility of adding some opportunities for students to engage with industry. These activities could include mini projects solving industry problems using industry data and equipment, tours of local and regional STEM industry facilities, visits to local community colleges or colleges, speakers and presenters at school, or even opportunities for low-level internships, to name a few.

Additionally, to the extent possible, grant leaders could encourage districts and schools to offer a wider variety of STEM content. With the exception of biology, content related to the top five career areas in which students expressed the most interest – veterinary work, medicine, engineering, biology and zoology, and medical science – is taught either occasionally or rarely.
Continue to support female students through project-based or hands-on learning experiences to improve attitudes toward STEM subjects and careers.

Multiple teachers described changes in the behaviors and engagement of their female students after they implemented their grant’s new curricula, interactive labs, or other hands-on activities. Activities in which students solve problems together in small groups seemed to unlock some communication and leadership skills of female students. These students would likely benefit if Golden LEAF STEM Initiative grants continue to implement problem-based STEM activities and opportunities for students to collaborate.

Survey results show that female students have significantly lower levels of interest than males in four STEM career areas: engineering, computer science, energy, and physics. Golden LEAF STEM Initiative grants could share this information back with their participating teachers and encourage educators to support their female students to gain awareness and confidence in these fields. If possible, grants should consider implementing additional activities that support female students to develop their interest in these fields, for example morning meetings, or lunch or after school clubs. Teachers and schools face significant time constraints and these activities could take place even twice a year in order to test their impact before implementing a more regular schedule.

Continue providing problem-based curricula and increase collaborative time or peer-to-peer learning opportunities among teachers that are dedicated to supporting the integration of STEM content.

Data collected from the focus groups with participating teachers suggests that the STEM curricula and materials implemented by the Golden LEAF STEM Initiative grants have helped increase the frequency with which content is integrated in classrooms. Problem-based STEM activities naturally require students to consider topics from across subjects, and teachers report that students are making connections more frequently. Feedback from participating teachers indicates that the new materials also helped them improve their instructional practice for integrating. Moving forward, Golden LEAF STEM Initiative grants should continue to give priority and attention to successfully implementing cross-curricular, hands-on STEM learning activities in order to increase the frequency of content integration.

Despite these successes, however, teachers participating in the focus groups still felt that there was room for improvement in the frequency and quality of content integration taking place in classrooms, including their own. They suggest that more time for collaboration between teachers of different subjects would enhance the teachers’ ability to integrate subjects successfully. This collaboration time could also help some teachers who are still reluctant to prioritize integrating content. Golden LEAF STEM Initiative grant leaders could make the case for more cross-subject collaborative time to those who do have the ability to change school schedules. Time is so precious that instead of looking for new blocks of time for teachers to collaborate, schools could consider coordinating small groups of teachers from across subjects to design integrated curriculum. Schools could leverage technology tools and programs for online networking.
socializing, and collaboration to provide other opportunities for peer learning among grant participants. A few elective teachers shared that they have a hard time collaborating with other teachers since they are often left out of planning meetings among faculty of core subjects. Special attention should be given to this issue, ensuring that STEM elective teachers are included in the work of the entire faculty.

**Increase the frequency of professional development opportunities that: provide resources, promote individualized learning goals, are content-specific, join teachers and industry professionals, and integrate subject-areas.**

In general teachers participating in the Golden LEAF STEM Initiative focus groups were appreciative of the professional development they received. They benefited the most from professional development opportunities that were hands-on, modeled instruction, and provided information about specific instructional resources.

Survey results show that, on average, the teachers participating in the Golden LEAF STEM Initiative had moderate levels of confidence in some aspects of their instructional practice. In addition they had mild expectations that, in general, any teachers’ actions can significantly impact students’ learning. This mixed results on teachers’ outcome expectancies identifies an opportunity for meaningful discussions among colleagues about core propositions in education.

In the focus groups teachers made a number of recommendations for trainings that would be especially useful. The educators suggested that they would benefit if grants, schools, or districts could provide teachers access to even more resources and references for STEM teaching — especially content-related resources (e.g. educational websites with materials for teachers) and instructional technology tools (e.g. computer programs or mobile applications). Teachers also indicated that they would like to have access to more content-specific professional development. The knowledge base in STEM fields frequently grows and changes and with so little time to research all of these topics on their own, STEM educators expressed a desire to have occasional opportunities for continuing education in their field. Additionally, findings from the teacher surveys indicated that elementary school teachers had slightly lower levels of confidence in aspects of their mathematics and science instructional practice. Content-specific professional learning opportunities in these subjects might be especially beneficial for elementary educators. Grants, schools, and districts might consider starting partnerships with community colleges or universities or providing access to online professional development in these fields. Similarly, grants, schools, or districts could provide more individualized professional development on specific topics instead of offering general sessions on basic skills.

**Continue to seek out ways to prioritize and fund a variety of technologies as instructional tools in STEM subjects.**

Conversations with participating teachers made it clear that there is a lack of advanced technology tools for STEM in their schools and districts. Teachers participating in Golden LEAF STEM Initiative grants which focused their resources on purchasing personal computers or classroom-level computers, like SmartBoards, reported significant benefits for student
engagement and learning. Advanced technology tools for STEM include not only personal computers, but other tools as well, such as three dimensional design software or equipment for producing and experimenting with solar power. In general, grant leaders should continue to match technology tools to program strategies and outcomes by following up directly with participating teachers. Leaders should ask what materials teachers most need to facilitate successful implementation of high-quality STEM curricula in their classrooms.

Seek out and promote scheduling solutions that provide more total time for students to learn STEM subjects and more flexible time for STEM activities that do not fit into regular school schedules.

A consistent theme from across conversations with teachers participating in the Golden LEAF STEM Initiative is the lack of sufficient time for high-quality STEM learning experiences. Some teachers expressed concern that there were not enough total class periods in a school year dedicated to STEM content, while others emphasized that individual class periods were too short to allow for meaningful inquiry-based learning of rigorous content. In general, both scenarios were problematic for teachers across the initiative.

Taken together with evidence that STEM subjects often naturally integrate with each other and include a significant amount of reading skills, grants should look for ways to increase time spent on the high-quality STEM learning activities that they are providing. Even though most Golden LEAF STEM Initiative grant leaders do not have the authority to change daily school schedules, they could lobby to others for creative ways to increase the total time dedicated to STEM learning and the frequency of extended periods of time.

V. Next Steps

The evaluation will continue into the spring of 2014 in an effort to understand the implementation and impact of the Golden LEAF STEM Initiative and to provide capacity-building support to grantees. Table 19 presents evaluation data collection activities and events that are planned for the fall and winter of 2012

Table 19
Upcoming Evaluation Activities and Events – Fall and Winter 2012

<table>
<thead>
<tr>
<th>Event</th>
<th>Topics</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Launching of on-demand survey administration</td>
<td>Live links to the edited, final student and teacher attitudes toward STEM surveys will be available for grantees to administer on their own, individual schedules</td>
<td>September 15, 2012</td>
</tr>
<tr>
<td>Administration of Pilot Leadership for STEM Programs Survey</td>
<td>Grant leaders and principals in participating schools take self-assessment survey</td>
<td>September – October 2012</td>
</tr>
<tr>
<td>Grant coordinator interviews</td>
<td>30 minute phone interviews with grant coordinators to discuss early Year 2 implementation</td>
<td>October 2012</td>
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The evaluation team has several upcoming deliverables as well (see Table 20).

Table 20
*Golden LEAF STEM Initiative Evaluation Deliverables, 2012-13*

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Period covered</th>
<th>Due date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1 Report</td>
<td>Fall 2012 – Fall 2013</td>
<td>March 29, 2013</td>
</tr>
</tbody>
</table>

CERE–NC looks forward to continuing its investigation of the impacts of the Golden LEAF STEM Initiative on STEM education outcomes in North Carolina schools.
References


