**Evaluation Section Summary: NSF Annual Report**

**September 2013**

This Annual Evaluation Report provides information about the QuarkNet program as it transitions to the current grant. This year’s (2012-2013) evaluation is also a transition between the previous Evaluation Matrix (see NSF Annual Report, Evaluation Section, September 2012) and a new matrix that matches the Strategic Plan for the current grant. The new Matrix focuses on evaluation of QuarkNet centers and data portfolios. While the evaluation of centers has not substantively changed, data portfolios are new and under development. Since this report addresses this transition, there were no data available to answer several study questions related to data portfolios, and, the report includes a *Transition Section* for which data were collected related to the previous Matrix. Questions from the new Evaluation Matrix are addressed below, preceded by a summary of findings and data collection and analysis for centers, then for data portfolios.

The evaluation data were collected between September 2012 and September 2013.

**Summary of Findings**

Below, is a summary of findings for the effectiveness of several program components, including those for which data were collected in this transition to the new Matrix.

**Centers**

Data on QuarkNet Centers were gathered by leadership fellows during their visits to institutes summer 2013, and spring telephone interviews and classroom visits to teachers from centers whose institutes they visited in summer 2012. Each year centers “considered to not be operating effectively” are suggested by QuarkNet staff to be evaluated. A teacher survey was conducted in the spring to a random selection of QuarkNet teachers. Findings indicate that, in general, the centers that were visited are operating as effectively as many others and the teachers are typical of those participating at other centers, therefore these data provide further information about centers in general.

***Institute Visits:*** During the summer of 2013, leadership fellows visited institutes at four QuarkNet centers. One center had a teacher institute and a student program. The centers were viewed by staff as struggling prior to the visits.

* The activities/projects offered at the four institutes gave the teachers an opportunity to explore research, inquiry practices and classroom implementation.
* The leaders at the centers appeared to be making great efforts to keep the programs going and increase the numbers of participants.
* The centers appeared to face obstacles that are common to many QuarkNet centers, in terms of mentors’ time and access to supplemental funds.
* Concerns expressed by the fellows about the centers have to do with the needs of the teachers in terms of technology and equipment; also funding and maintaining communities.

***Teacher Interviews:*** During 2013 teachers were interviewed by leadership fellows during a classroom visit and during institute visits and by telephone. Twenty-five teachers were interviewed. Of those only two did not teach physics; 17 reported participating in QuarkNet activities such as summer institutes and masterclasss.

* Teachers reported they engaged in activities that supported QuarkNet goals of increasing their knowledge of particle physics and involving their students in working with data and with research projects. They said the types of activities provided at institutes included: building/ maintaining Cosmic Ray detectors or other equipment, lectures, tours, introductory particle physics, implementing particle physics in the classroom, planning and sharing teaching ideas, Cosmic Ray e-labs and ongoing student research projects. Participation in national QuarkNet was: Cosmic Ray e-lab, Masterclass, Boot Camp, CMS e-lab, LIGO e-lab, Teaching & Learning Fellows, LHC Fellows, CMS Fellow and trip to CERN.
* Direct connections for how to implement QuarkNet in their classrooms varied from making lesson plans and games as a group to learning information on fundamental particles, conducting independent research projects, data analysis with detectors, inquiry-based instruction, modern physics topics, videoconferences, using detectors, demonstrations by professors for classroom transfer.
* Supports to centers include mentors and teacher leaders at the centers and staff teachers at the national level. Leadership at the centers is mostly done by the mentors. Of the 17 responses related to leadership, 10 were mentors, four were mentors and teachers and three were teacher leaders. There were seven responses about center mentors’ activities and interactions with the teachers. The support they offer is in the form of organizing workshops, setting up detectors, contacting participants, instructing on how to implement QuarkNet and running a student research program. Twenty teachers commented that QuarkNet Staff teacher support included: detector support, moral support, Friday Flyer, Emails/Calls/Support, runs masterclass and presents at QuarkNet “meeting.” Most of the teachers could identify the staff teacher assigned to their center; three could not.
* There were 42 total instances of teachers implementing QuarkNet activities at lower duration of one-to-two or three-to-five lessons compared to 29 instances of longer durations of one to two weeks, or long-term projects. Other topics included scientific inquiry, cloud chambers and engineering design. QuarkNet teachers who teach grades 10-12, and higher-level classes tended to engage students in lessons or projects of longer duration. Those teaching lower grades implemented topics such as *Particle Adventure* and the Standard Model in one or two lessons rather than long-term projects, and tended not to be involved in professional activities as much as those who teach higher grades.
* Based on past data, teachers who are more experienced in QuarkNet usually participate in activities that indicate a high degree of professionalism, which is known to contribute to successful QuarkNet centers. This year 12 (40%) have given workshops that include local and district physics gatherings, mini-workshops, professional development, State STA, AAPT, LIGO and particle physics workshops. Twenty-two (88%) of the teachers have attended meetings of professional organizations such as AAPT (One helped host an AAPT session), NSTA, State STA, State APT, School & university meetings. Twenty-one have been involved in leadership at their schools in the following capacities: department chair, technology mentor/committees, curriculum/science task force, policy review/site council or recruiting QuarkNet teachers and students.

*Classroom Visits:* Fellows visited nine teachers’ classrooms.

* All of the teachers appeared to be dedicated to introducing particle physics content or current topics in science and research in their classrooms, barring equipment and technology challenges. While in most cases, the topics introduced were not related to particle physics, the teachers exhibited several “best practice” strategies, especially inquiry and research-based projects, which are advocated by QuarkNet
* Based on the ratings of their students’ classroom habits and class activities, five to seven of the teachers included inquiry. All nine of the teachers engaged in instructional strategies, and seven of the nine focused on instructional emphases that reflected inquiry-based teaching and learning. Seven of the teachers had students work in groups or pairs, indicating collaborative efforts. About half (4 - 6) involved inquiry in their discussions and hands-on work.

***Teacher Survey:*** The survey was placed online by QuarkNet staff in early spring of 2013. The overall response rate this year was 54 per cent after exhaustive efforts to achieve a greater number of responses, therefore could not be said to represent QuarkNet teachers. These data, however, did indicate that results are similar to past results, when there was a random sample. In addition, findings corroborated much of the data collected by fellows during interviews and site visits.

* Survey responses revealed that both the practices that support inquiry-based learning, collaboration and research and those that do not support were used at high frequencies. This year’s data show more frequent use of those practices that are not considered to be best practice, according to national standards, by more experienced QuarkNet teachers, possibly indicating a decline over time.
* Teachers participate in programs and activities that support learning communities and professional development as evidenced by the numbers of teachers who have made QuarkNet-related presentations (10 or 17%), shared information with colleagues (48 or 82%), developed new materials for courses (45 or 60%) and held leadership roles in their schools and districts (14 or 23%).
* As in past years, teachers have attended a high number (116) of QuarkNet programs other than their local summer institute: Cosmic Ray e-lab and Teaching and Learning workshops, masterclass and Boot Camp. Therefore, programs offered nationally and not only center-related, are being attended at high rate.
* Responses indicated that teachers used resources and topics in the classroom that included Cosmic Ray Detector, Cosmic Ray e-lab, *Particle Adventure*, Standard Model, LHC Web Site, CMS e-lab and LIGO e-lab. Teachers widely used particle physics examples such as Conservation Laws, Momentum, Vectors, Energy, Nuclear physics/energy and Energy–Mass conversion (E=mc2).

**Data Portfolios**

Data Portfolios are being developed to address three levels of student engagement with data: 1) Introductory Activities; 2) in-class and national/international CMS/ATLAS masterclass; 3) CMS, Cosmic Ray, LIGO e-labs. This year data portfolios were under development, therefore data on support structures, feedback from participants were not available.

***CMS masterclass workshops:*** There were several Data Workshops conducted this summer that were the precursor to CMS masterclass workshops, levels 1 and 2 of data portfolios. One workshop was observed for formative evaluation purposes. Following are “best practices” that were observed:

* A lot was covered but did not feel rushed. Relevant and appropriate information was provided then teachers were referred to resources to access; not too much (more is less) was addressed nor was anything substantive left unaddressed.
* Scientists’ talks were at an appropriate level. Teachers‘ questions were answered at their level of understanding. The atmosphere encouraged an easy exchange between mentors and teachers, teachers and facilitators.
* Activities were done in groups so that teachers could experience them as would a student, then discussed as adults and as teachers, i.e., classroom implementation. Teachers had plenty of opportunity to interact with the data and engage in activities in pairs or groups. The workshop was an excellent model for how to organize and conduct the activities and data analyses with their students.
* Implementation was discussed throughout and focused on each day and at the end of the workshop. Teachers were left with multiple ways to engage students with particle physics and specifically with CMS data.

***Student e-Lab Posters*:** In several teachers’ classes and/or clubs, students who conducted an e-lab (level 3) were asked to complete a poster. The expectations in general were that the students achieve a layman’s understanding of the particle physics and scientific process included in the e-lab. There were three kinds of e-lab posters: LIGO, CMS and cosmic ray. The posters assessed were selected at random therefore *represent* the posters submitted overall.

* Overall, the LIGO and cosmic ray student posters did not meet expectations using the new (2011) rubric; the CMS posters exceeded expectations to a small extent using the 2010 rubric. Most missing are students providing evidence to support their claims and critically analyzing the results such as for validity.
* There were few discernible patterns to what works and what does not in conducting an e-lab. Whether honors or college or just regular physics, the duration, resources used and the extent the teacher reflects that the e-lab was effective, appears to depend more on what the teacher expects. If the expectation is just to complete a research project, the teacher appears to be satisfied.
* Two significant patterns in the contextual data were: 1) long-term projects using e-labs that focus on research and include the science are effective in achieving expectations as described in the rubric; 2) e-labs appear to fulfill the objectives and standards for conducting research to a great extent. In some contexts, the e-lab uniquely addresses some standards, especially those related to scientific research.

***CMS e-Lab Workshops:*** CMS e-lab workshop participant surveys were collected from 50 respondents from four centers, between June and August, 2013. E-lab workshops prepare teachers to implement level 3 of data portfolios.

* Positive responses to survey items such as “My understanding of the material increased.” appeared to contribute to preparing the participants to implement having their students work with data at levels 3.
* Comments from teachers indicate that the workshops were not consistent in terms of the participants being at the same level for understanding the content, and that the facilitators varied in their presentation of the material. For example, when asked “What related topics would you like to know more about, their comments ranged from, “Are there any teacher guides? I'm still making sense of it myself” to “Pseudorapidity improving analysis techniques.” Comments also indicated some of the workshops provided broader content and others basic information about analyzing CMS data.

**Transition**

The purpose was to gather data to confirm findings from three-to-four years of evaluation that shows the student research program and national/international CMS/ATLAS masterclasses are mature programs and effective; effective practices for each are included in the body of the *Metrics* section of this annual report.

***Student Research Programs****:* The data largely represent students participating in research programs; data from 71 percent of centers providing student research programs and 64 percent of students participating in the programs were used in the analyses. There is actually not one student research program since each site conducts the program somewhat differently and with different research. It is the program overall that has been shown to be effective in increasing scientific literacy.

* A T-test analysis indicated that the difference in pre- and post-test scores was statistically significant. This year there was only a slightly statistically significant difference between pre- and post-tests (P = .03). In previous years the differences were <.01 and even <.001. The smaller significance this year may have been due to a larger response rate in which students who may not have completed tests, especially post-tests, in the past were completing tests.
* This year, as in the past, qualitative data from pre- and post-tests indicate a more in-depth understanding of scientific methodology. Chains of thought indicated a better idea of how scientists engage in actual research, as opposed to a linear, “The” scientific method. Since the ‘pre’ indicates what students learn in school, it is clear that this research experience leads to a more complete understanding of how scientific research is actually carried out.

***National CMS/ATLAS Masterclass:***It is unclear the extent to which the data *represent* QuarkNet national CMS/ATLAS masterclasses overall since surveys were provided from 13 of 19 sites (65% response rate). However of the data collected, there was a 93 percent response rate for students and an estimated 92 percent response rate for teachers. Again, masterclass is not one program but several in that each site has different facilitators, presenters and slightly different processes, such as some have tours a few do not. Overall, the students matched the demographic shown to have the more positive experiences and outcomes from attending masterclass (MC) with regard to grade level (96%) and being enrolled in a physics class (82%). Over the years, masterclass data show it is effective in increasing students understanding of particle physics as well as the instruments used to collect data, authentic data analysis and nature of scientific research.

* All but five of the 36 teachers who completed surveys used topics, activities, resources with their students to prepare them for MC. Several teachers who reported not using or using few resources, commented that in the future they would prepare their students better next year. Teachers reported that the resources and support for MC were “very good” at means of 4.4 to 4.7 out of ‘5’.
* Students were asked how much they know the several particle physics-related terms before MC, then they were asked the extent to which they had learned something new about the terms through MC. For each, there were statistically-significant differences (<.001) between pre-and post-survey responses. After attending MC, 68 percent of students reported they were more interested in physics.
* Students rated all aspects of MC more toward “interesting,” “easy to understand” and “good” (means of 3.1 to 3.8 out of 5). Videoconferencing at some sites continued to have technical issues, mostly related to quality of sound. Teachers rated the aspects higher than students at means of 3.9 to 4.7. When students were asked the extent to which they liked the masterclass they attended the overall mean was a 4.1 out of 5 with a low standard deviation of 0.8. The majority (65%) also reported that the level was “exactly right.” Overall, student and teacher opinions of MC were positive.