

**Evaluation of the QuarkNet Program:  
Evaluation Report 2020-2021  
Executive Summary**

Kathryn Race  
Race & Associates, Ltd.

The QuarkNet Collaboration, referred to as QuarkNet, “is a long-term, national program that partners high school science teachers with particle physicists working in experiments at the scientific frontier.” QuarkNet is a professional development program that “immerses teachers in authentic physics research and seeks to engage them in the development of instructional strategies and best practices that facilitate the implementation of these principles in their classrooms; delivering its professional development (PD) program in partnership with local centers” (Program Theory Model, PTM, 2019). There are approximately 50 plus such centers across the United States.

**Program Goals**

The measurable program goals of QuarkNet (as articulated by the Principal Investigators, PIs of the program and as stated in the Program Theory Model) are:

1. To continue a PD program that prepares teachers to provide opportunities for students to engage in scientific practices and discourse and to show evidence that they understand how scientists develop knowledge. To help teachers translate their experiences into instructional strategies, which reflect guided inquiry and NGSS science and engineering practices.
2. To sustain a national network of independent centers working to achieve similar goals. To provide financial support, research internships, an instructional toolkit, student programs and professional development workshops. To investigate additional funding sources to strengthen the overall program.
3. To reenergize teachers and aid their contributions to the quality and practice of colleagues in the field of science education.
4. To provide particle physics research groups with an opportunity for a broader impact in their communities.

**Overview of Report**

This report is a prototype of the final evaluation report of this program to be submitted at the end of this award period; as such, it presents a draft of the final evaluation report (although as an interim report it is final). In serving as a prototype, the present report and its review demonstrate the shift in evaluation efforts from formative (and summative) assessment to an outcomes-based evaluation. One advantage of this early look is that it

gives QuarkNet program staff members opportunities to better understand this shift and to share in this process. And, it has offered opportunities for staff to identify principal needs and concerns that the evaluation may be able to be responsive to; and to give the evaluator time to adjust to these needs and suggestions proposed by staff to help aid in the usefulness of evaluation findings and recommendations.

The evaluation focused on the following: (1) Develop (and use) a Program Theory Model (PTM); (2) Assess program outcomes at the national and center levels through teacher-level outcomes; and, (3) Assess the sustainability of program centers based on center-level and sustainability outcomes.

The fully-articulated PTM is complete. Both the process used to create it and the PTM have been described in detail in this report. Ideally, a program theory model offers a cohesive and representative picture of the program, "an approximate fit" of the program as *designed*. We have sought consensus on the representativeness of this model with key stakeholders and will revisit the PTM over the course of the award period, as this is needed.

To a large extent the PTM elaborates on how change is expected to occur, based on the following QuarkNet Theory of Change:

*By immersing teachers in doing authentic particle physics research and by engaging them in professional development that supports guided-inquiry and standards-aligned instructional practices and materials designed for the classroom, teachers become empowered to teach particle physics to their students in ways that model the actual practices of scientists and support instructional best practices suggested by the educational research literature.* (Modified from Beal & Young, QuarkNet Summative Evaluation Report 2012-2017).

The development of a PTM and a Theory of Change is consistent with common guidelines proffered by the Institute of Education Sciences, U.S. Department of Education and the National Science Foundation (2013). Weiss (1995) noted that grounding evaluation in theories of change means integrating theory with practice. She postulated further that making assumptions explicit and reaching consensus with stakeholders about what they are trying to do, and why, and how, may ultimately be more valuable than eventual findings (Weiss, 1995), having more influence on policy and popular opinion (Rallis, 2013).

We have used the PTM to direct the evaluation including the development of evaluation measures and methods designed to address the remaining two goals. To this end, we have created three evaluation measures, these are: a Full Teacher Survey, an Update Teacher Survey, and a Center Feedback Template. As implied, the first two measures assess teacher-level outcomes; and the third measure assesses center-level outcomes. The first administration of the Teacher Survey coincided with the start of summer workshops that occurred in 2019; and the roll-out of the Center Feedback template began in September 2019. To coincide with the 2020-2021 program year, we have added an Update: Teacher

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Survey to continue to capture information from participating teachers and to focus on classroom implementation of QuarkNet content and instructional materials.

Based on 2019 and 2020 survey efforts, 355 teachers have completed the full Teacher Survey (this represents a unique count). A total of 90 teachers completed the Update Survey with 69 of these responses matched with responses from the original full survey. This represents a 78% response rate for 2019; and, 72% for 2020. We are grateful to QuarkNet staff who have added time to participate in the survey into nationally-led workshop agendas (and encouraged this for center-led workshops); and to teachers for their thoughtful responses to these survey requests.

Our approach to analysis has been to explore, preliminarily, teacher perspectives based on scale scores created from like items on the full Teacher Survey. These are self-reported exposure to Core Strategies of the program; Approach to Teaching; QuarkNet's Influence on Teaching; Student Engagement; and, QuarkNet's Influence of Student Engagement. We also looked at self-reported use of activities from the Data Activity Portfolio. The Update Survey focuses on subsequent classroom implementation of these activities as well as revisiting the teacher-level outcomes of Approach to Teaching and Student Engagement. These results are supplemented with information gathered from the QuarkNet Center Feedback process (15 Centers are presently included in the analysis mix) to help provide the context in which the teachers engage in the program and to assess center-level outcomes in their own right. We have focused on exploring consistent patterns in the data and to use multiple sources whenever possible (e.g., teacher responses, center responses, and information from workshop agendas and annual reports of active centers).

In preliminary analyses ....

Regarding **Core Strategies**, program engagement and exposure to core program strategies (as perceived by teachers) were shown to be related in a meaningful way. That is, more engagement by type of QuarkNet event was related to perceived higher exposure to core strategies; and more reported use of activities from the Data Activities Portfolio in the classroom. This speaks to the fidelity of the *implemented* program as compared to the program as *designed* as perceived by participating teachers; and, to the usefulness of this measure in subsequent outcomes analyses.

Regarding, **Approach to Teaching**, teaching outcomes were shown to be related to *perceived* QuarkNet's Influence on Teaching, Use of DAP activities in the classroom, and exposure to Core Strategies (based on results from multiple regression analyses). Of importance, Use of DAP activities and Core Strategies scores can serve as surrogate measures for degree of engagement in a variety of QuarkNet programs (e.g., Data Camp, Variety of Workshops, and Masterclass engagement) and degree of exposure to strategies seen as core to the program; this helps to simplify the model. A split-half analysis (based on teachers from 15 centers) suggests that this model is stable; and, thus Use of DAP activities and Core Strategies can be used as measures shown to be statistically related to teachers' Approach to Teaching. We continue to explore the use of center-level measures

to help improve this model and to better understand the impact of offering teachers QuarkNet programs nested within partner-centers.

Regarding, **Student Engagement**, Approach to Teaching and QuarkNet's Influence on Student Engagement (at least) were shown to be related to perceived student engagement in inquiry-based science. This model, however, was less stable, based on a split-half analysis; thus, we continue to work to build a representative model of the impact of the program on student engagement as perceived by QuarkNet teachers.

Although preliminary, the weight of analyses (based on single-variable analyses and multiple regression models) suggests that there is a positive relationship between engagement in QuarkNet (the type and degree of program engagement and use of activities from QuarkNet's Data Activities Portfolio), exposure to Core Strategies, perceived influence of QuarkNet on Teaching; and teacher outcomes (Approach to Teaching). Regarding the engagement of their students in inquiry-based science (that aligns with the NGSS Science and Engineering practices), teachers' perceived Approach to Teaching and QuarkNet Influence on Student Engagement (at least) were shown to be related to Student Engagement. We continue to explore ways in which these statistical models can be improved including integrating center-level assessments into this process.

In assessment of the process of conducting center-level information through the Center Feedback Template, results from the pilot test and two additional rounds of outreach suggest that this process has been helpful for QuarkNet staff teachers, the centers themselves (mentors and lead teachers), and the evaluation (based on 15 centers to date). Using information from this process, along with information obtained from workshop agendas, and annual reports from active centers we have explored responses based on individual teacher perceptions and center-level assessments. In the main, there has been concurrence across information sources. For example, results from the teacher survey and feedback from centers suggest that teachers typically engage in activities as active learners. Similarly, both individual teachers and centers report opportunities for teachers to interact with other teachers, mentors and other scientists and to help foster collegial, long lasting, relationships. Moreover, activities from the Data Activities Portfolio, *as designed*, align well with the Next Generation Science Standards science practices, and *as implemented* through QuarkNet workshops (based on workshop agendas) and as evidenced by center-level assessment of these practices by participating teachers at their center.

Finally, responses from the Update Survey have provided a preliminary look on what (and how) activities from the Data Activity Portfolio are used (or planned to be used) by QuarkNet teachers in their classrooms. Although currently presented at the raw response level, we seek to integrate this information – either qualitatively or quantitatively – to help inform the outcomes analyses described in this report.

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## Program Summary and Recommendations

It is important to note that nearly all of the 2020 workshops and masterclasses, with few exceptions, were conducted in a virtual environment – and all occurred during a turbulent time of considerable uncertainty as to the severity and longevity of the COVID-19 pandemic. We have described how COVID-19 (coronavirus) has impacted the implementation of the 2020 QuarkNet program year; and how this has continued into the 2021 program year. Virtual workshops held in 2020 were reduced in scope focused on core concepts; and converted, for example, to half-day sessions with small-group breakout sessions, separate off-line time to work on specific tasks, and breaks built into the agenda. Programs in 2021 were held (or planned to be held) in in-person and/or virtual environments. With important input from QuarkNet staff, we have outlined the long-term possible implications of many of these program modifications.

The following program summary and recommendations are proffered:

1. The program has had a long-standing practice of holding regularly-scheduled staff meetings. One is staff-wide; one is specific to IT concerns; and, one is specific to program content and development. The evaluator has been invited to attend these weekly meetings, and she has regularly attended the staff-wide meeting. Of importance, these weekly meetings have been especially helpful in discussing and planning program content and delivery modifications as a result of coronavirus, COVID-19 during the 2020 and 2021 program years. The staff-wide meeting has provided a convenient and frequent means for staff and the evaluator to exchange ideas, such as opportunities to highlight evaluation results and for the evaluator to learn and respond to program needs when possible. Continue to hold these meetings as feasible by everyone's schedule as these are of value to both the program and the evaluation.
2. Starting in the 2019-2020 program year, there has been a concerted effort by QuarkNet staff to help nationally- and center-led workshops document the content of their workshops through the development and use of agenda templates. This is a simple and pragmatic step that is very valuable. These agendas can and have been modified and used by QuarkNet centers. In many cases, agendas are modified during the event which memorializes the program in a just-in-time fashion. These documented agendas can help centers prepare their annual reports, which each participating center is asked to do.
3. Documenting workshop agendas and center annual reports – and posting these on-line -- have been extremely helpful in gathering information useful to the evaluation. Specifically, the workshop agendas improved our ability to identify which (and how) activities from the Data Activities Portfolio (DAP) have been incorporated into workshops, especially nationally-led workshops and to a lesser extent but still notable for center-led workshops. Other information gathered from these sources helps to summarize program year QuarkNet engagement by centers in general, and specifically in helping centers to complete the Center Feedback template. We have also used this information for *as designed* and *as implemented* comparisons; and in comparing individual teacher- and center-level response similarities/differences. For

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these reasons (plus benefits noted in 2) continue to encourage centers to use the agenda template options to create their own.

4. DAP activities, collectively, have been shown to align well with Next Generation Science Standards Science and Engineering Practices. QuarkNet staff has provided operational definitions to support how this alignment is determined and has also shown the alignment of these activities with Enduring Understandings of Particle Physics. Of importance, these activities are a bridge for teachers to implement QuarkNet content and materials into their classrooms. As a result of COVID-needed modifications, many of these activities can now be implemented in on-line environments expanding implementation options for teachers. Continue to maximize the use of Data Portfolio Activities by teachers at center-led and nationally-led QuarkNet workshops and meetings; and to encourage teachers' classroom implementation of these activities either in-person, on-line (or both).
5. Starting with the 2020-2021 program year, staff created a guide to help teachers reflect on and develop implementation plans that can be incorporated into teachers' classrooms using QuarkNet content and instructional materials. Staff members have mandated this discussion in nationally-led workshops and they have strongly encouraged its use in center-run workshops. Based on early results, this structured approach has helped teachers reflect on classroom plans in meaningful ways. This information along with responses gathered from the Update Teacher Survey is very valuable to the outcomes evaluation. Continue to support this effort.
6. The number (and the quality) of activities in the DAP has increased dramatically from 2017 (the end of the past grant period) to the new program-award period. This has included applying the review and restructuring of previously developed activities, offering activities by graduated student skill-sets, and, separating activities by data strand and curriculum topics. As the number of these activities has grown so has the work-load for their development and eventual use. Consider adding a Project Coordinator position to QuarkNet staff in the future renewal funding. This person could help the education specialist with DAP activity development as well as have other responsibilities related to gathering and updating program-operations data such as helping to track participation related to registration, updating teacher profiles on the QuarkNet website; and subsequent stipend payment.
7. When feasible, encourage centers to meet during the school year in support of and to augment summer-led events. Although there are other issues such as time commitments and scheduling within a school year, the familiarity and necessity of remote meetings via Zoom during the 2020 and 2021 program years may help centers move in this direction.
8. Reflect on ways in which the Program Theory Model may be used to inform others in the program, those participating in the program (including centers), and those external to program. The brief one-page summary of the PTM and preliminary evaluation results might help in this effort.
9. Kudos to QuarkNet staff for a roll-out of a series of mini-workshops for lead teachers at QuarkNet centers (started in the 2021 program year and planned to be continued in subsequent program years). Given that all QuarkNet centers are mature, staff realized that there was need to clarify the roles and responsibilities of lead teachers and to give these teachers a platform to exchange ideas on these possibilities.

10. Continue to support the evaluation and its efforts as reasonable; and continue to work with the evaluator, as planned, to help embed evaluation efforts and requirements within the structure and delivery of the program.

### **Evaluation Summary and Recommendations**

The following evaluation summary and recommendations are proffered:

1. The response rates for the full Teacher Survey and the Update Survey remain high over the 2019 and 2020 program years (78% and 72%, respectively). This success is due to the commitment of QuarkNet staff teachers, fellows, and center mentors in allocating time during their workshops and meetings for this purpose. We acknowledge and are grateful for this commitment.
2. Working with QuarkNet staff, the Update Teacher Survey dovetails well with the guidelines for teachers in the development of classroom implementation plans. As the number of teachers who complete the Update Teacher Survey grows, we anticipate using this information to help illuminate how and in what ways teachers have planned or have used QuarkNet program content and practices in their classrooms. And, to the degree possible we will link this implementation to the type and degree of engagement by teachers in QuarkNet, either qualitatively or quantitatively.
3. Continued efforts to distribute and collect center-level information through the Center Feedback Template suggest that this process has been helpful for QuarkNet staff, Center level mentors and lead teachers, and the evaluation. To date, we have information from 15 Centers that have been incorporated into analyses. Additional centers will be added into the mix and incorporated into future analyses.
4. Preliminary analyses from the Teacher Survey suggest that there is a meaningful link between exposure to program strategies and program engagement; and that this engagement along with use of activities from the Data Activities Portfolio and teachers' perceptions of QuarkNet's Influence on Teaching are related to teacher outcomes. Perceived student engagement was shown to be related to teachers' Approach to Teaching and QuarkNet's Influence on Student Engagement.
5. Data analyses suggest agreement between center-level perceptions and teacher-level perceptions. This is evident when looking at information about teachers experiencing activities as active learners (as students); and, exposure to opportunities to develop and maintain collegial relationships with other teachers, mentors and other scientists. We have also shown that activities from the Data Activities Portfolio, *as designed*, align well with the Next Generation Science Standards Engineering Practices and *as implemented* based on workshop agendas as well as the perceptions of participating teachers and feedback from QuarkNet centers.
6. Continue to incorporate center-level outcomes data (from the Center Feedback Template process), in analyses of teacher-level outcomes (and in particular the regression models). Add sustainability outcomes into the mix as the number of participating centers grows.

7. Work with program staff to help articulate ways in which the PTM can be used and how to facilitate this use. This includes seeing the PTM as representative of the program (as an “approximate fit”) and the value of its Theory of Change. The one-page summary of the PTM and evaluation results may help in this process.
8. Continue to be mindful of the many responsibilities that program staff, mentors and teachers have. Work to ensure that evaluation requests are reasonable and doable in a timely manner. And to the extent possible, embed evaluation requests and efforts within the structure and delivery of the program.
9. Work to ferret out the benefits and challenges of implementing QuarkNet programs (workshops, masterclasses) in a virtual environment and work with QuarkNet staff to highlight positive long-term implications of this over time.
10. Work to ensure that evaluation efforts and results are of value (or of potential value) to all those involved in the process. This includes QuarkNet staff and network of partners, participating teachers, NSF and others who may be interested in QuarkNet.