



# **Evaluation of the QuarkNet Program: Evaluation Report 2023-2024 Executive Summary**

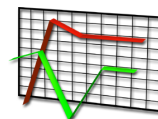
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## QuarkNet Evaluation Executive Summary: 2023- 2024

Since the start of the 2019 QuarkNet program year, the evaluation themes are: (1) (Develop and) Use a Program Theory Model (PTM); (2) Measure Outcomes (teacher, student and long-term); and (3) Measure Center-level Program Outcomes. During the previous grant period, new evaluation measures based on the PTM were created; these were combined with selected previous evaluation measures. We seek to link program engagement, as articulated through program strategies, to measurable program outcomes (see Figure 1).



Figure 1. Throughout the evaluation, program engagement (i.e., specifically exposure to core program strategies) provides the context in which assessment has occurred.

The evaluation report overviews QuarkNet’s program goals, the Program Theory Model and theory of change based on this model, the 50+ QuarkNet centers, alignment of activities in the Data Activities Portfolio, workshops conducted during the 2022-2023 program year summarized in a table, highlighted teacher demographics and program engagement, and teacher, student, long-term, and center-level outcomes. Results of both quantitative and qualitative analyses nested by centers offer a narrative of program impact. Program and evaluation recommendations are proffered.

### **Program Theory Model (PTM): What’s New and What’s Kept**

QuarkNet’s PTM was reviewed and revised (in small but important ways) to coincide with the current renewal grant. To this end, we had added: a new partner (i.e., the Institute for Research and Innovation in Software for High Energy Physics, IRIS-HEP); added new program components; and, reviewed, updated and revised descriptions of other program components, as needed. The programmatic anchors of the PTM focus on characteristics of effective professional development (Darling-Hammond, Hyler and Gardner, 2017); NGSS Science and Engineering Practices (NGSS, April 2013); and an operational definition of inquiry (Herron, 1971 as modified by Jan-Marie Kellow, 2007). And the details of the PTM describe the major partners, program goals, program components of QuarkNet, articulating program strategies and their linkage to expected outcomes.

### **Evaluation Measures and Sources of Information**

The evaluation measures and sources of information that have been used to inform the evaluation are shown in Exhibit A. These measures align with the PTM.

<b>Sources of Outcomes Data</b>
<b>Teacher Full Survey</b> Primary Focus: Quantitative analyses of teacher, student, and long-term outcomes
<b>Update Survey</b> Primary Focus: Qualitative analyses of QN content and material use in classrooms
<b>Center Feedback Process and Template</b> Primary Focus: Comparing center-level and teacher-level responses
<b>Virtual Workshop Visits by Evaluator</b> Primary Focus: Implementation plan discussions
<b>Multiple Sources of Information: Evidence of Program Engagement/ Alignment with PTM</b>
<b>Workshop Summary Table compiled from:</b> Workshop Agendas Annual Reports from Centers
<b>Data Activities Portfolio alignment with:</b> NGSS Science Practices Workshop Engagement Enduring Understandings
<b>Acknowledge and Review other Information</b> (e.g., cosmic ray studies, use of comic watches, professional presentations; masterclasses; student-collected data)

Exhibit A. Summary and Overview of Evaluation Measures and Program Engagement

## Summary of Evaluation Results

The summary of evaluation results is highlighted in Table 1, using the outline highlighted below to achieve this purpose. The narrative of the evaluation report details support for the conclusions presents for each of the following:

1. Survey Implementation and Response Rates
2. Program Fidelity: *Designed* vs. *Implemented* Program
3. Summary of QuarkNet Teachers: Demographics
4. School Characteristics and Student Demographics
5. Unique Contribution of Major QN Program Components
6. Quantitative Analyses: Teacher, Student and Long-term Outcomes
7. Qualitative Analyses: Center-level Portfolios
8. Center-level Outcomes and Effective Practices
9. Getting the Word Out

Table 1  
QuarkNet Evaluation: Summary of Major Efforts and Results

Evaluation Effort	Source of Information(s)	Highlighted Major Results
<b>1. Survey Implementation and Response Rates</b>	<ul style="list-style-type: none"> <li>• Full Teacher Survey</li> <li>• Update Teacher Survey (English and Spanish versions)</li> </ul>	<ul style="list-style-type: none"> <li>• Survey implemented during workshop participation with follow-up email as necessary.</li> <li>• Survey response rate range (2019-2023) from 78% to 80%.</li> </ul>
<b>2. Program Fidelity: <i>Designed vs. Implemented Program</i></b>  Measured through the alignment of NGSS Science Practices	<ul style="list-style-type: none"> <li>• Data Activities Portfolio (DAP)</li> <li>• Workshop Agendas</li> <li>• Center Annual Reports</li> <li>• Completed Center Feedback Templates</li> </ul>	<ul style="list-style-type: none"> <li>• DAP activities as <i>designed</i> shown to align well with NGSS Science Practices.</li> <li>• Workshop agendas incorporate DAP activities; these <i>implemented</i> activities align well with NGSS Science Practices.</li> <li>• Center-level responses from Center Feedback Templates indicate that QuarkNet teachers engaged in NGSS Science Practices as part of their workshop engagement; and this experience has a noted influence on teachers related to these practices.</li> </ul>
<b>3. Summary of QuarkNet Teachers: Demographics</b>		
<b>a. Teacher Gender</b> (not statistically related to outcomes)	<ul style="list-style-type: none"> <li>• Full Teacher Survey</li> </ul>	<ul style="list-style-type: none"> <li>• Program engagement close to parity (~ 55% men; ~45% women)</li> </ul>
<b>b. Years in QuarkNet</b> (balancing professional development that is sustained as well as attracting new teachers)	<ul style="list-style-type: none"> <li>• Full Teacher Survey</li> </ul>	<ul style="list-style-type: none"> <li>• Approximately 33-36% of teachers are new/1-year engagement in QuarkNet.</li> <li>• Mean number of years ~5 years</li> <li>• Median number of years 2.0 years</li> </ul>
<b>c. School Location</b>	<ul style="list-style-type: none"> <li>• Full Teacher Survey</li> </ul>	<ul style="list-style-type: none"> <li>• ~ 48% of teachers represent schools in urban locations</li> </ul>
<b>d. Teacher Physics</b>	<ul style="list-style-type: none"> <li>• Full Teacher Survey</li> </ul>	<ul style="list-style-type: none"> <li>• ~ 80% of teachers teach Physics</li> <li>• Other fields mentioned include Chemistry, Physical Science, Earth Sciences, Statistics, Math</li> </ul>
<b>e. Program Year Participation</b>	<ul style="list-style-type: none"> <li>• Full Teacher Survey</li> </ul>	<ul style="list-style-type: none"> <li>• Outcomes do not vary by which year a teacher participates in QuarkNet.</li> </ul>

Table 1 (con't.)  
 QuarkNet Evaluation: Summary of Major Efforts and Results

Evaluation Effort	Source of Information(s)	Highlighted Results
<p><b>4. School Characteristics and Student Demographics</b>            (based on publicly available school-level information)</p> <p><b>a. Location</b>  <b>b. Enrollment size</b>  <b>c. Student: Gender (%), Ethnicity/ Race (%); Free or Reduced Lunch (%)</b></p>	<ul style="list-style-type: none"> <li>• Large scale case study</li> <li>• Either <a href="http://www.publicschoolreview.com">www.publicschoolreview.com</a> or <a href="http://www.privateschoolreview.com">www.privateschoolreview.com</a></li> <li>• Information accepted at face value.</li> <li>• Based on teachers enrolled in QuarkNet during 2022 program year.</li> <li>• ~ 250 teachers from ~120 schools.</li> </ul>	<ul style="list-style-type: none"> <li>• Organized by center.</li> <li>• Schools represented by QuarkNet teachers are varied; representing mostly public schools both large and small; and, to a lesser extent, private schools. Some centers show evidence that students represented by schools are diverse in ethnicity and represent notable percents of low-income students (e.g., free or reduced lunch eligibility). Other centers less so.</li> </ul>
<p><b>5. Unique Contribution of Major QuarkNet's Program Components</b></p> <p><b>a. Data Camp</b>  <b>b. (Variety of) Workshops</b>  <b>c. Masterclasses</b></p>	<ul style="list-style-type: none"> <li>• Full Teacher Survey (Program Exposure and Outcome Scale Scores: Core Strategies, Approach to Teaching, QuarkNet's Influence on Teaching, Student Engagement, QuarkNet's Influence on Student Engagement, and Long-term Outcomes: Teachers.</li> <li>• Series of simultaneous Analysis of Variance (ANOVA) analyses</li> <li>• Because of sample limitations these analyses do not consider the important role played by Centers.</li> </ul>	<ul style="list-style-type: none"> <li>• Statistical analyses support the use of scale scores as program exposure/outcome measures.</li> <li>• These analyses suggest that Data Camp and Variety of Workshops each contribute to teachers' reported exposure and engagement in Core Strategies.</li> <li>• Each major program component of QuarkNet contributes uniquely to at least one or more outcome measures: Approach to Teaching; QuarkNet's Influence on Teaching, Student Engagement (as reported by teachers), QuarkNet's Influence on Student Engagement; and Long-term Teacher Outcomes.</li> <li>• Thus, these analyses suggest that each of the major components of QuarkNet contribute <i>uniquely</i> to outcomes as measured.</li> </ul>

Table 1 (con't.)  
 QuarkNet Evaluation: Summary of Major Efforts and Results

Evaluation Efforts	Source of Information(s)	Highlighted Results
<b>6. Quantitative Analyses: Teacher, Student and Long-term Outcomes</b>	<ul style="list-style-type: none"> <li>• Full Teacher Survey</li> <li>• Hierarchical linear regression analyses that account for teachers nested in QuarkNet Centers.</li> <li>• Using scale scores to measure outcomes.</li> </ul>	<ul style="list-style-type: none"> <li>• QuarkNet Centers <i>matter</i> when assessing teacher, student, and long-term outcomes. (See below for short summary of each.)</li> </ul>
<b>a. Approach to Teaching</b>	<ul style="list-style-type: none"> <li>• Scale Scores: Core Strategies, Approach to Teaching, QuarkNet's Influence on Teaching and Center-level Mean Scores (Approach to Teaching)</li> </ul>	<ul style="list-style-type: none"> <li>• A hierarchical linear regression analysis based on these 26 centers (34 combined) explored the relationship between QuarkNet program engagement and Approach to Teaching. The results of this analyses suggest that QuarkNet's Influence on Teaching, Core Strategies and Centers (as measured by mean Approach to Teaching Scores) are shown to be positively related to teacher use of content and instructional practices in their classrooms (i.e., Approach to Teaching). These results are statistically significant [<math>F_{(3, 388)} = 73.85, p &lt; .001</math>].</li> </ul>
<b>b. Student Engagement</b>	<ul style="list-style-type: none"> <li>• Scale Scores: Student Engagement, QuarkNet's Influence on Student Engagement, Approach to Teaching and Center-level Student Engagement Mean.</li> </ul>	<ul style="list-style-type: none"> <li>• This hierarchical linear regression analysis was based on 25 (33 combined) centers. The results of this analyses suggest QuarkNet's Influence on Student Engagement, Approach to Teaching and Centers (as measured by mean Student Engagement scores) have a positive relationship on this Student Engagement. These results are statistically significant [<math>F_{(3, 329)} = 106.53, p &lt; .001</math>].</li> </ul>
<b>c. Long-term Outcomes</b>	<ul style="list-style-type: none"> <li>• Scale Scores: QuarkNet's Influence on Teaching, Student Engagement and Long-term Outcomes</li> </ul>	<ul style="list-style-type: none"> <li>• Again, using a hierarchical linear regression analysis, Perceived QuarkNet's Influence on Teaching, Student Engagement and Center-level Means (Long-term Outcomes) are positively and statistically related to Long-term Outcomes: Teachers [<math>F_{(4, 306)} = 48.42, p &lt; .001</math>].</li> </ul>

Table 1 (con't.)  
 QuarkNet Evaluation: Summary of Major Efforts and Results

Evaluation Efforts	Source of Information(s)	Highlighted Results
<p><b>7. Qualitative Analyses: Center-level Portfolios</b></p> <p>(compiled for centers included in the quantitative analyses)</p>	<ul style="list-style-type: none"> <li>• Full Teacher Survey (open-ended questions)</li> <li>• Update Survey (open-ended questions)</li> <li>• Virtual workshop site visits by evaluator</li> <li>• Teacher Implementations Plans (workshop agendas/center annual report)</li> <li>• Examples of teachers' work</li> <li>• Examples of student work</li> </ul>	<p>Organized by center, portfolios are comprised of:</p> <ul style="list-style-type: none"> <li>• Teachers reported planned or actual use of QuarkNet content and materials in their classroom over time (based on survey responses).</li> </ul> <p>When available:</p> <ul style="list-style-type: none"> <li>• Implementation plans prepared by teachers or groups of teachers and posted on QuarkNet website are included.</li> <li>• Examples of teacher work (during workshop, science fairs, presentations at workshops/professional conferences) are included.</li> <li>• Examples of student work are included.</li> </ul>
<p><b>8. Center-level Outcomes and Effective Practices</b></p>	<ul style="list-style-type: none"> <li>• Center Feedback Template</li> <li>• Effective Practices (M.J. Young &amp; Associates (2017, September). <i>QuarkNet: Matrix of Effective Practices</i>)</li> </ul>	<ul style="list-style-type: none"> <li>• Comparisons suggest good agreement on select responses by individual QuarkNet teachers and QuarkNet centers [25 (34 combined) centers].</li> <li>• Results suggest good alignment of centers to meet the criterion of each of 10 effective practices.</li> <li>• Offers a suggestion of program sustainability (i.e., what is being sustained).</li> </ul>
<p><b>9. Getting the Word Out</b></p>	<ul style="list-style-type: none"> <li>• <a href="https://quarknet.org/content/publications-presentations-and-posters-sept-2018-sept-2023">https://quarknet.org/content/publications-presentations-and-posters-sept-2018-sept-2023</a> Compiled by K. Cecire and S. Wood</li> </ul>	<ul style="list-style-type: none"> <li>• As of the 2023 program year, QuarkNet has posted a total of 72 presentations, posters, and publications.</li> <li>• In 2024, include success stories from former students, QuarkNet teachers, fellows, and staff.</li> </ul>

## Program Summary and Recommendations

The following program summary and recommendations are proffered:

P1. 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 regularly attended the staff-wide meeting. These weekly staff-wide meetings provide 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. This meeting structure was essential during COVID for the evaluator (and likely QuarkNet staff as well). Going forward the evaluator has attended weekly staff-wide meetings as her schedule has permitted; this open invitation is greatly appreciated.

Recommendation P1: The frequent opportunity to exchange ideas among staff members as well as the evaluator is important and should be continued.

P2. Over the course of the grant period, the collection of program operations data has improved substantially including for example, simple counts, e.g., number of participating teachers during a given program year. QuarkNet staff have the responsibility of managing workshop RFP's and the award of monies to conduct these efforts as well as tracking teachers to award stipends. These efforts are managed well as are attempts to gather a complete list of registered teachers, although these responsibilities are shared across QuarkNet staff rather than the responsibility of one individual.

Recommendation P2: Continue to improve the collection of program operations to help facilitate both program and evaluation efforts. In keeping with these efforts, improved program operations data has helped with a running count of *new* teachers in QuarkNet each year across participating centers. It also may help to provide insight into the outreach to additional teachers who are not as directly engaged in QuarkNet who nevertheless benefit from the program in other ways.

P3. Starting in the 2019, and continuing during the 2020 through 2023 program years, 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. These agenda examples are readily available and offer 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.

Recommendation P3: Continue to support these efforts.



P4. Documenting workshop agendas and center annual reports – and posting these online -- have been extremely helpful in gathering information useful to the evaluation. Specifically, the workshop agendas improved the ability to identify which (and how) activities from the Data Activities Portfolio (DAP) have been incorporated into workshops, especially nationally-led workshops and a growing number of 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 comparisons of the *designed* and *implemented* program; and in comparing individual teacher- and center-level response similarities/ differences.

Recommendation P4: For these reasons (plus benefits noted in 3) continue to encourage centers to use the agenda template options to create their own and to post these on the QuarkNet website.

P5. As evident in the narrative of this report, the Data Activities Portfolio has grown substantially during this past grant period and into this new period. Of importance DAP activities, collectively, have been shown to align well with Next Generation Science Standards Science and Engineering Practices. To this end, QuarkNet staff have provided operational definitions to support how this alignment is determined. The DAP activities have also been aligned with the Enduring Understandings of Particle Physics. Noteworthy, these activities are a bridge for teachers to implement QuarkNet content and materials into their classrooms. Many of these activities were modified for online uses expanding implementation options for teachers (with COVID the impetus for this effort). These options can now be used to support in-person instruction. Early efforts have translated several of these activities (and supportive resources) into Spanish. Teacher and student resources have been added; and older activities have been updated, modified, or even removed as scientific knowledge has advanced.

Recommendation P5: The dynamic effort that underlies the DAP is acknowledged and program support to maintain this effort is encouraged.

P6. The number (and the quality) of activities in the DAP has increased dramatically from 2017. 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 workload for their development and eventual use.

Recommendation P6: Consider adding a select group of lead teachers or fellows to help in this process in the future. These individuals could help the education specialist with DAP activity development as well as have other responsibilities related to updating and augmenting resource information related to these activities.

P7. During the past and present grant period, QuarkNet staff have demonstrated to teachers how to access DAP activities on the website; demonstrated search options and the availability of supportive resources such as teacher notes and student notes. Participating teachers often have had the opportunity to engage in these activities as active learners (as students) and to reflect on their possible use during implementation plan development and discussion that is part of the agendas of the workshops.

Recommendation P7: Continue program efforts 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.

P.8 Starting with the 2020-2021 program year, staff created an implementation plan template 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 this inclusion in center-run workshops. Many of these implementation plans are posted on the QuarkNet website. Early results suggest that this structured approach, that is, time for planning and discussion as well as the implementation templates over a variation of it, -- has helped teacher frame their classroom plans in meaningful ways. It is likely that these program efforts have made it easier for teachers to respond to implementation questions asked in the Update Survey(s). These efforts are valuable for the teachers and are very valuable for the evaluation. Because of these efforts, many implementation plans created by teachers have been incorporated into center-level portfolios that include other qualitative data as well.

Recommendation P8: Continue to incorporate the use of these templates (or a variation of it) and encourage teachers to post these on the QuarkNet website. Documenting these implementation plans will substantially help in providing the narrative as to the *how/what/why* QuarkNet content and materials are used in their classroom. In keeping with this, "coding camps" and workshops use a protocol of "share-out spreadsheets" where implementation plan coding projects are regularly posted by participating teachers. Adopting something similar to this protocol may aid in the consistent documentation of these proposed efforts across all QuarkNet workshops and programs. Regularly posting implementation plans may encourage teachers to post other examples of how QuarkNet content and materials are incorporated into their classrooms.

P9. Sustained duration is among the characteristics of effective professional development identified by Darling-Hammond et al (2017).

Recommendation P9: QuarkNet has been a long-standing program. To support the sustained duration of the program for participating teachers throughout the year, 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 online remote

meetings during the 2020-2023 program years may help centers move in this direction.

P.10. The Program Theory Model offers an approximate fit of QuarkNet as designed and provides a road map as to how change is expected to occur.

Recommendation P10: 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 the program.

Although not recommendations per se a few additional thoughts are warranted.

Credit goes 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 again in the 2023 program year). Given that nearly all QuarkNet centers are mature (except for a few new centers), staff have taken this opportunity to clarify and expand the roles and responsibilities of lead teachers and to give these teachers a platform to exchange ideas on these possibilities.

QuarkNet staff have proposed during this grant period to hold a series of focus groups across several participating centers (one such meeting was held on December 16, 2023, at the Rice University/University of Houston QuarkNet Center) to help broaden participation to reach more teachers and students who are underrepresented in STEM. This and planned focus groups are intended to augment the in-roads made during this past grant period, through such outreach efforts as the development of STEP-UP classroom materials; or STEAM workshops intended to incorporate art with science concepts and Native American culture as well as increasing the number of schools that serve underrepresented students through representation by QuarkNet teachers.

Finally, QuarkNet staff has done outstanding work to support evaluation efforts and to help embed evaluation efforts and requirements within the structure and delivery of the program. This is reflected in a standing invitation for the evaluator to attend staff-wide weekly meetings, setting aside time during the workshop for the completion of Teacher Surveys (either the full or shorter update versions), as well as coordinating with centers for the Center Feedback process and the virtual workshop site visits by the evaluator during teachers' discussions of implementation plans. The success of the evaluation's implementation is due to this cooperation by QuarkNet staff and is greatly appreciated. As is the participating teachers' willingness to complete the survey (both full and update versions) in a timely and frank manner.

## Evaluation Recommendations

The following evaluation summary and recommendations are proffered:

E1. The response rates for the Full Teacher Survey and the Update Survey remain high over the 2019 through 2023 program years (ranging between 78% to 80%). Survey links have been embedded in the agendas of workshops to help facilitate a high response rate. 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; and to participating teachers who complete it.

Recommendation E1: Continue to work with QuarkNet staff in their support of evaluation efforts.

E2. The Update Teacher Survey dovetails well with the in-workshop discussions by teachers about implementation plans. These discussions have served the evaluation well (and likely the program) as it provides teachers with a quick means to capture their thoughts in describing how and in what ways teachers plan to or have used QuarkNet program content and materials in their classrooms when completing the Update Survey. During the 2023 program year, there has been an important uptick of teachers posting implementation plans which is very important to help qualitatively describe implementation in-roads of QuarkNet content and materials in the classroom.

Recommendation E2: With QuarkNet staff help, increase the number of teachers who post their implementation plans or ideas on the QuarkNet website.

E3. The use of the Update Teacher Survey has allowed a more in-depth descriptive analysis of the *how/what/why* of the use of QuarkNet content and materials by teachers in the classroom (and reduces the ask of teachers to supply evaluation information) over time. The linking of these surveys (both full and updates) by individual teachers has provided a valuable picture of how these plans and QuarkNet content/material use may have changed over time as participation in QuarkNet continues. Both the review of posted implementation plans and responses from the Update Teacher Survey have helped to provide the story or narrative behind the results of the quantitative analyses; this information is now captured in center-level portfolios along with examples of teacher/student work. (These portfolios are consistent with the use of *authentic assessment* as a means to evaluate performance, “teaching for understanding and application rather than for rote recall.” Darling-Hammond & Snyder, 2000, p. 523.)

Recommendation E3: These qualitative analyses have been expanded during this grant period to provide a more in-depth descriptive look at classroom implementation of QuarkNet content and materials across centers and the program overall. This effort should be continued as these qualitative analyses help to provide a narrative of what

classroom implementation of QuarkNet content and materials looks like. Add examples of teacher work, student work, and presentations/posters given at professional conferences when available.

- E4. The Center Feedback Template process continues to provide valuable information to compare individual teacher- and center-level views on teacher engagement and on center-level outcomes. For the near future this effort may be put on the back burner and revisions to this process may be explored. This is the case, in part, because the most active centers and those most likely to align their center-level efforts with the national program as well as the Program Theory Model have completed the process.

Recommendation E4. Going forward, we will explore two ends; first, a quick and easy method to assess centers so that individual and center level responses can be compared. Second, it is expected that this revised process will be designed to help jump start or re-ignite centers to help increase their engagement in QuarkNet.

- E5. Per recommendation by NSF, we revamped the preliminary quantitative analyses to investigate the unique contribution major QuarkNet components play in the measurement of program engagement and outcomes. These analyses suggest that Data Camp and Variety of Workshops each contribute to teachers' reported engagement in Core Strategies, and that each major program component of QuarkNet contributes uniquely to at least one or more outcome measures: Approach to Teaching; QuarkNet's Influence on Teaching, Student Engagement (as reported by teachers), QuarkNet's Influence on Student Engagement; and Long-term Teacher Outcomes. Thus, these analyses suggest that each of the major components of QuarkNet contribute uniquely to outcomes as measured.

Recommendation E5: Continue to explore the unique contribution of major QuarkNet program components with the caveat that these analyses do not take into consideration the center in which teachers engage in the program (because of sample size limitations).

- E6. *Centers Matter*. Teachers principally participate in QuarkNet through centers suggesting the statistical need to account for this nesting of teachers within these centers. Thus, a hierarchical linear regression analysis based on 26 centers (34 combined) explored the relationship between core program strategies, perceived influence QuarkNet has had on classroom teaching practices and implemented instructional practices (Approach to Teaching). The results of this analysis show that QuarkNet's Influence on Teaching, Core Strategies and Centers (as measured by mean Approach to Teaching Scores) are shown to be positively related to teacher use of content and instructional practices in their classrooms (i.e., Approach to Teaching). These results are statistically significant [ $F_{(3, 388)} = 73.85, p < .001$ ].

Recommendation E6: Continue to analyze teacher-level outcomes based on nested centers and increase the inclusion of as many teachers and centers in these analyses as is feasible and that meets analysis criteria.

- E7. Similarly for Student Engagement, the center in which the teacher participates in QuarkNet *matters*. Thus, a hierarchical linear regression analysis [(based on 25 center (33 centers))] was conducted where QuarkNet's Influence on Student Engagement, Approach to Teaching and Centers (as measured by mean Student Engagement scores) were shown to be positively related Student Engagement [ $F_{(3, 329)} = 106.53, p < .001$ ].

Recommendation E7: Modelling student-level outcomes through analyses continue to be challenged where a wide variety of possible relationships may exist suggesting that a stable, reliable model has remained elusive. That said, continue to explore student-level outcomes analyses based on nested centers with the hope that additional data will help to stabilize these results.

- E8. Long-term outcomes by participating QuarkNet teachers were measured in a similar fashion. That is, perceived QuarkNet's Influence on Teaching, Student Engagement and Center-level means scores are positively and statistically related to Long-term Outcomes: Teachers [ $F_{(4, 306)} = 48.42, p < .001$ ].

Recommendation E8: Since this is the first iteration of these analyses (Long-term Outcomes: Teachers), seek to replicate these findings with additional data collected during subsequent program years.

- E9. Qualitative analyses have supported the results of these quantitative analyses by providing descriptive details including examples of classroom implementation plans of QuarkNet content and materials by participating teachers. This information has been compiled in center-level portfolios (as already mentioned) which have included: teacher responses to open-ended survey questions over time as to the *what/how/why* of classroom implementation; examples of implementation plans created by teachers, as well as examples of teacher work, and student work. Examples of presentations at professional conferences are included as well, when available.

Recommendation E9: Continue to explore the development and use of these center-level portfolios.

- E10. Continue to 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.

Recommendation E10: It is important that the evaluator remains mindful of the many responsibilities of QuarkNet program staff, mentors and teachers. 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 as has been done during this grant period. In addition, 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, advisory board members, participating teachers, NSF and others who may be interested in QuarkNet.