Evaluation Results:2025

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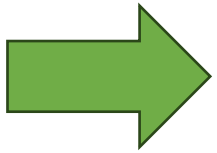
Evaluation Themes

Focus

Develop (and use) Program Theory Model (PTM)

Measure Outcomes (Teacher, Student and Long-term)

Measure Center-level Program Outcomes

Program Strategies  **Measurable Program Outcomes**

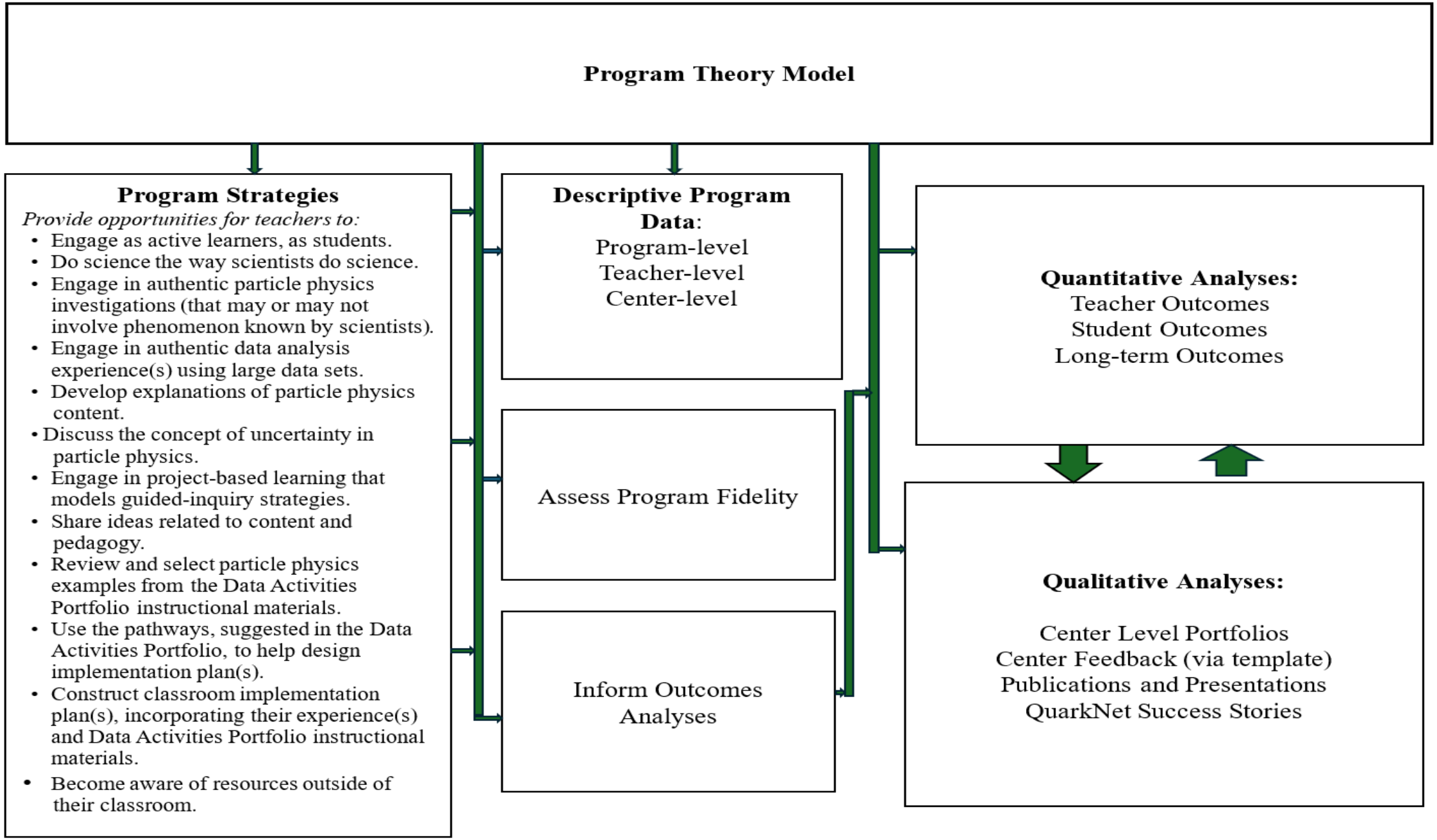


Exhibit F. Overview of Program and Outcomes Data ✓

Multiple Sources of Information

Sources of Outcomes Data

Teacher Full Survey
Primary Focus: Quantitative analyses of teacher, student, and long-term outcomes
Update Survey
Primary Focus: Qualitative analyses of QN content and material use in classrooms
Center Feedback Process and Template
Primary Focus: Comparing center-level and teacher-level responses
Virtual Workshop Visits by Evaluator
Primary Focus: Implementation plan discussions

Multiple Sources of Information: Evidence of Program Engagement/ Alignment with PTM

Workshop Summary Table compiled from:
- Workshop Agendas
- Annual Reports from Centers

Data Activities Portfolio alignment with:
- NGSS Science Practices
- Workshop Engagement
- Enduring Understandings

Acknowledge and Review other Information
(e.g., cosmic ray studies, use of comic watches, professional presentations; masterclasses; student-collected data)

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

Evaluation Report Organization

Summary of Evaluation Results

The summary of evaluation results is highlighted in Table 15, using the outline highlighted below to achieve this purpose. The narrative of the evaluation report uses this organization and has detailed support for the conclusions presented for each of the following:

1. QuarkNet: Professional Development for HS Teachers
2. (Develop and) Use a Program Theory Model
3. Program Organization
4. Data Activity Portfolio: Brief History and Development
5. Program Implementation and Measuring Fidelity (*Designed* vs. *Implemented* Program)
6. Linking Program Strategies to Outcomes
7. Survey Implementation and Response Rates
8. Summary of QuarkNet Teachers: Demographics
9. School Characteristics and Student Demographics
10. Overview of Analyses: Teacher (and their Students) and Long-term Outcomes
11. Unique Contribution of Major QN Program Components
12. How QuarkNet Engagement is Related to Outcomes: QuarkNet Centers *Matter*
13. Qualitative Analyses: Center-level Portfolios A Narrative Picture of QuarkNet's Influence
14. Center-level Outcomes and Effective Practices
15. Getting the Word Out
16. QuarkNet Success Stories: Case Studies
17. Program and Evaluation Recommendations

Table 15
QuarkNet Evaluation: Summary of Major Efforts and Results

Evaluation Effort	Source(s) of Information	Highlighted Major Results
1. QuarkNet: Professional Development for HS Teachers Appendix A highlights program history.	• Review of previous program and evaluation documents • QuarkNet staff expertise	• Brief program history presented. • Importance of Centers noted. • Four Program Goals presented. • Approach to evaluation provided (three themes).
2. (Develop and) Use a Program Theory Model Appendix B summarizes the protocol used to develop this model. Appendix C presents the full model (PTM).	Created by working groups based on: • Structured interviews with key QuarkNet staff • Relevant literature • QuarkNet staff expertise PTM is intended to reflect that *context matters* in the implementation of the program providing a representative picture of how *change* is expected to happen.	• In detail (7 pages) PTM outlines the links between core program strategies, program structure and major program outcomes. (See Appendix C.) • Offers a 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.*
3. Program Organization (See Figure 2 for chart.) (See Table 1 for list of QuarkNet centers.)	• Organization and Implementation chart (developed by QuarkNet staff) • Program's website https://quarknet.org/	• Overviews the administration and implementation of the program. • Key role of centers noted (presently 55 centers). • Importance of QuarkNet's website presented.
4. Data Activity Portfolio: Brief History and Development Appendix D overview protocol. Appendix E presents a brief history of Data Activities Portfolio (DAP) growth. (See Tables 2-4.)	• *The Data Portfolio is a compendium of particle physics classroom activities organized by Data Strand, Level of student engagement, Curriculum Topics and NGSS Standards*. (Data Activities Portfolio QuarkNet) • Organized by key search options • Pathway and Template documents created to support development of activities • Supported with resources (e.g., teacher/student notes)	• Organized by required student skills sets (Levels 0-4) (developed by QuarkNet staff). • Criteria used to determine the alignment of DAP with Next Generation Science Standards (NGSS) defined by QuarkNet staff. (See Table 2 in full report.) • DAP *as designed* aligns well with Next Generation Science Standards (NGSS), (see Table 3) and • QuarkNet's defined Enduring Understandings (see Table 4). • Grown to include 40 plus activities, designed to be implemented in the classroom. Several can be implemented online and several are in Spanish.

Table 15 (con't.)
QuarkNet Evaluation: Summary of Major Efforts and Results

Evaluation Effort	Source(s) of Information	Highlighted Major Results
5. Program Implementation and Measuring Fidelity (*Designed* vs. *Implemented* Program) Previous program years are highlighted in a series of tables in Appendix F. (See Table 5 in evaluation report for 2024 program year summary.)	• Program Theory Model • Workshop Agendas • Center Annual Reports • Virtual site visits by the evaluator	• Workshop summary tables highlight the *implemented* QuarkNet program. (See Table 5.) • Workshop agendas incorporate DAP activities offering opportunities for teachers to engage in these as active learners. • *Implemented* activities align well with NGSS Science Practices (see Figure Set 14). • Creates predicate to compare program engagement to program outcomes (presented here shortly).
6. Linking Program Strategies to Outcomes Appendix G presents a series of tables that link core program strategies to relevant education literature, followed by linking core strategies to program outcomes. Appendix H presents Full Teacher Survey. Appendix I presents Update Survey. Appendix J presents Center-level Feedback Template.	• Program Theory Model • Linking Program Engagement to Outcomes (evidence of program engagement) • Sources of Outcomes Data delineated • Appendix K shows statistical support for use of scale scores	• Overview outcomes data sources: • Teacher Full Survey • Update Survey (Spanish language version also) • Center Feedback Process and Template • Virtual Workshop Visits by Evaluator
7. Survey Implemented and Reponses Rates (See Table 6.)	• Teacher surveys (full/update) were conducted during 2019-2024 program years • Survey implemented during workshop participation with follow-up email as necessary • Raw data from the full teacher survey and the update survey • Data retrieved from Survey Monkey • Raw data cleaned and multiple data calculations and all analyses conducted using IBM SPSS version 28	• Annual survey responses (including combined full and update versions for years when relevant) range from a low of 72% (during COVID) to 80% during the 2019-2023 program years. • 83% response rate for 2024 program year.

Table 15 (con't.)
QuarkNet Evaluation: Summary of Major Efforts and Results

Evaluation Effort	Source(s) of Information	Highlighted Major Results
8. Summary of QuarkNet Teachers: Demographics		
a. Gender of Teachers (not statistically related to outcomes) (See Table 7.)	Full Teacher Survey	• The number and percent of women who participate QuarkNet has increased over recent program years. • Over the 2019-2024 program years program engagement is close to parity: 50% for men; 43.6% for women; and 6.4% not specified (based on survey data). • From 2024 program registration information, 48% are men. 47% are women and 5% preferred not to answer.
b. Teachers *New* to QuarkNet Appendix L presents these data by QuarkNet center and program years.	• Full Teacher Survey • Operations Data (teachers receiving stipends)	• For 2019-2022 program years, 36% of teachers were new/1-year in program. • For the 2023 program year, this percent was 33%. • In 2024 program, 33% of teachers were new/1-year in program (information from attendance records and survey responses).
c. Years in QuarkNet, Years Teaching and Years at Current School (See Figure Set 4.)	• Full Teacher Survey (at the time teachers completed their survey)	• Based on teacher reports, the mean number of years in QuarkNet is 4.62 years (median 2.0 years). • Mean number of years teaching is 16.12 years (median 15 years). • Mean number of years at current school is 9.09 years (median 7 years).
d. School Location (See Table 8.)	• Full Teacher Survey	• Over 50% (51.3%) of schools where participating teachers teach are in urban/urban central city locations. • 29.5% of schools are in suburban locations. • 19.2% of schools are in rural locations.
e. Teaching Physics (See Table 8.)	• Full Teacher Survey (at the time teachers completed their survey)	• A total of 74.8% of teachers reported teaching physics. • Over time, there has been a tendency for more teachers to report that they are not teaching physics. • Other fields mentioned include Chemistry, Physical Science, Earth Sciences, Biology, Statistics, Math. • Slightly more women report that they do not teach physics as compared to men.

Table 15 (con't.)
QuarkNet Evaluation: Summary of Major Efforts and Results

Evaluation Effort	Source(s) of Information	Highlighted Major Results
8. Summary of QuarkNet Teachers: Demographics (con't.)		
f. QuarkNet Participation (See Tables 9-10.) (See Figure 6.)	Full Teacher Survey	• Any and all programs (as reported when survey was completed) that teachers participated in at the time they completed their full survey. • Program engagement linked to exposure to core program strategies.
g. QuarkNet Participation and Program Year (See Table 11.)	Full Teacher Survey	• Outcomes do not vary by which year a teacher participates in QuarkNet.
9. School Characteristics and Student Demographics (based on publicly available school-level information) **a. Location** **b. Enrollment size** **c. Student: Gender (%), Ethnicity/Race (%); Free or Reduced Lunch (%)**	• Large scale case study • Either www.publicschoolreview.com or www.privateschoolreview.com • Information accepted at face value. • Based on teachers enrolled in QuarkNet during the 2022 program year. • ~ 250 teachers from ~120 schools.	• Organized by center. • 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.
10. Overview of Analyses: Teacher (and their Students) and Long-term Outcomes (See Figure 7.)	• Full Teacher Survey: Quantitative Data Analyses	• Maps out key outcomes analyses • Statistical analyses support the use of scale scores as program exposure/outcome measures. • Outcomes measures are: Core Strategies (exposure), Approach to Teaching, QuarkNet's Influence on Teaching, Student Engagement (as perceived by teachers), QuarkNet's Influence on Student Engagement and Long-term Outcomes.

10. Overview of Analyses: Teacher (and their Students) and Long-term Outcomes

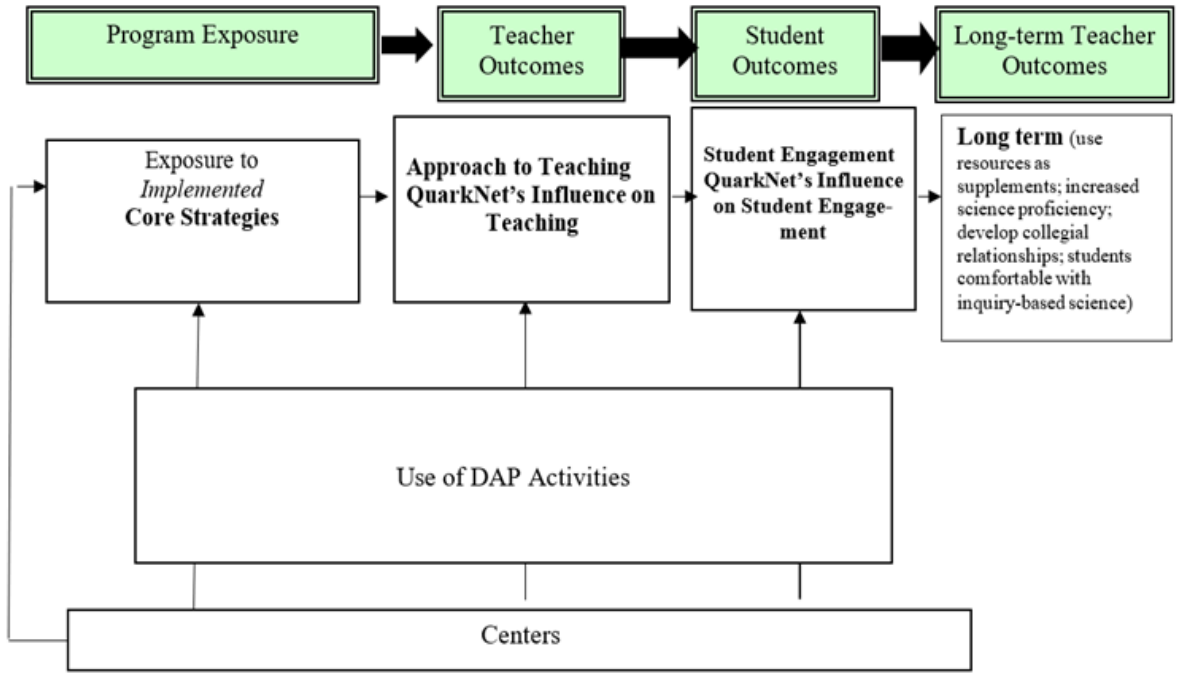
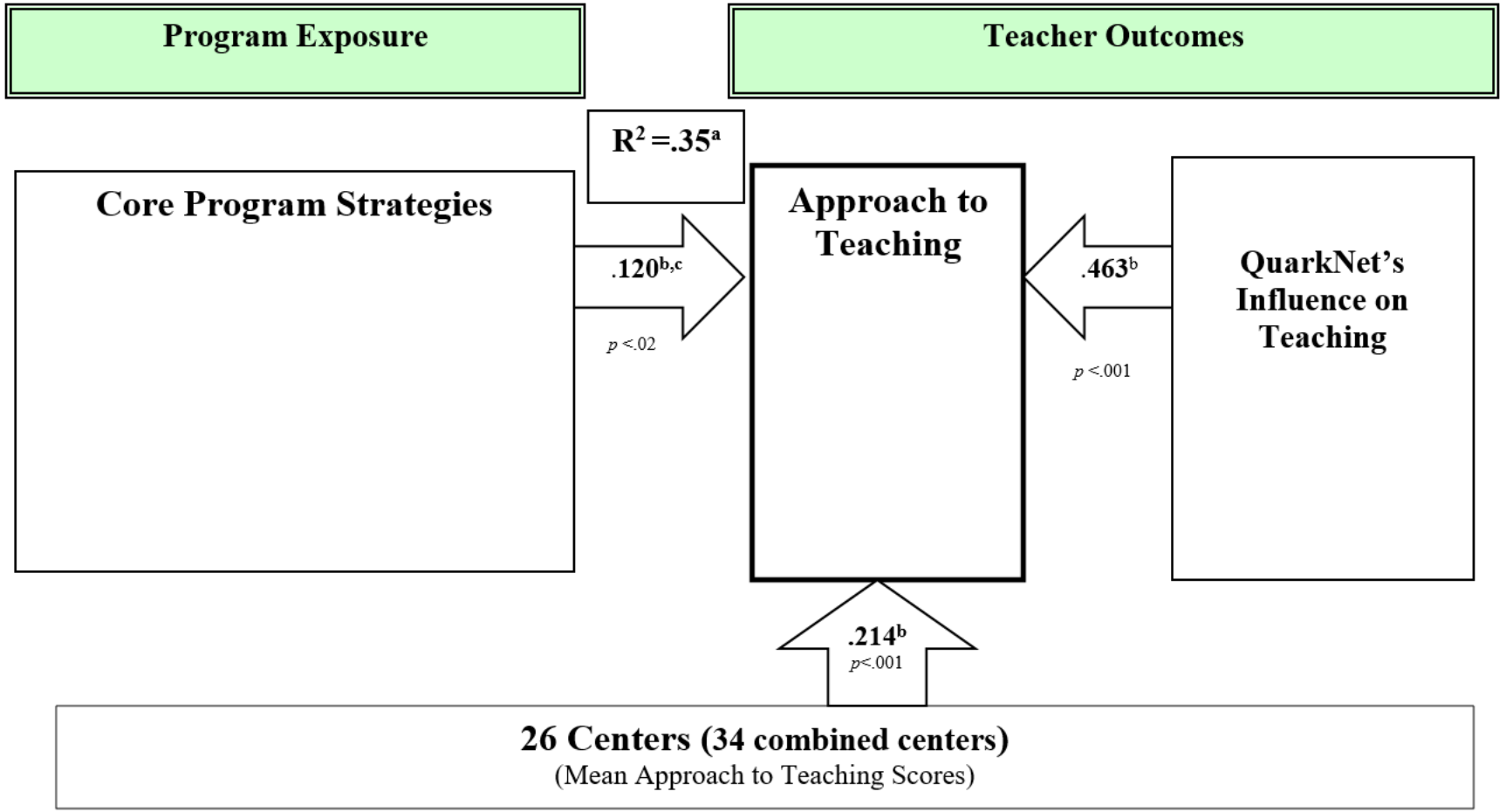


Figure 7. Teacher (and their Students) and Long-term Outcomes: Overview of Analyses

Table 15 (con't.)
QuarkNet Evaluation: Summary of Major Efforts and Results

Evaluation Effort	Source(s) of Information	Highlighted Major Results
11. Unique Contributions of QuarkNet Program Components **a. Data Camp** **b. (Variety of) Workshops** **c. Masterclasses** (See Table 12 in full report.) Appendix L presents summary of results and analysis details.	• 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.) • Requested by NSF. In response, conducted a series of simultaneous Analysis of Variance (ANOVA) analyses	• 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. (See Table 12 in full report.) • Thus, analyses suggest that each of the major components of QuarkNet contribute *uniquely* to outcomes as measured. • Analyses do not take into consideration the role that centers play in engagement and outcomes (do not meet statistical requirements for such analyses).
12. How QuarkNet Engagement is Related to Outcomes: QuarkNet Centers *Matter* **a. Approach to Teaching** (See Figure 9-10.)	• Full Teacher Survey • Hierarchical linear regression analyses that account for teachers nested in QuarkNet Centers. • Using scale scores to measure outcomes. • Scale Scores: Core Strategies, Approach to Teaching, QuarkNet's Influence on Teaching and Center-level Mean Scores (Approach to Teaching)	• See Figure 8 for a schematic on the relationship between program engagement and exposure to core program strategies. • QuarkNet Centers *matter* when assessing teacher, student, and long-term outcomes. (See below for short summary of each.) • A hierarchical linear regression analysis based on 26 centers (34 combined) explored the relationship between QuarkNet program engagement and Approach to Teaching. The results of this analysis 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 teachers' use of content and instructional practices in their classrooms (i.e., Approach to Teaching). These results are statistically significant $[F_{(3, 424)} = 77.32, p < .001]$. See Figures 9-10.



Reliability Coefficients:

Core Program Strategies	0.88
Approach to Teaching	0.87
QN's Influence on Teaching	0.95

$F_{(3, 424)} = 77.32, p < .001$

[a]Percent variance explained

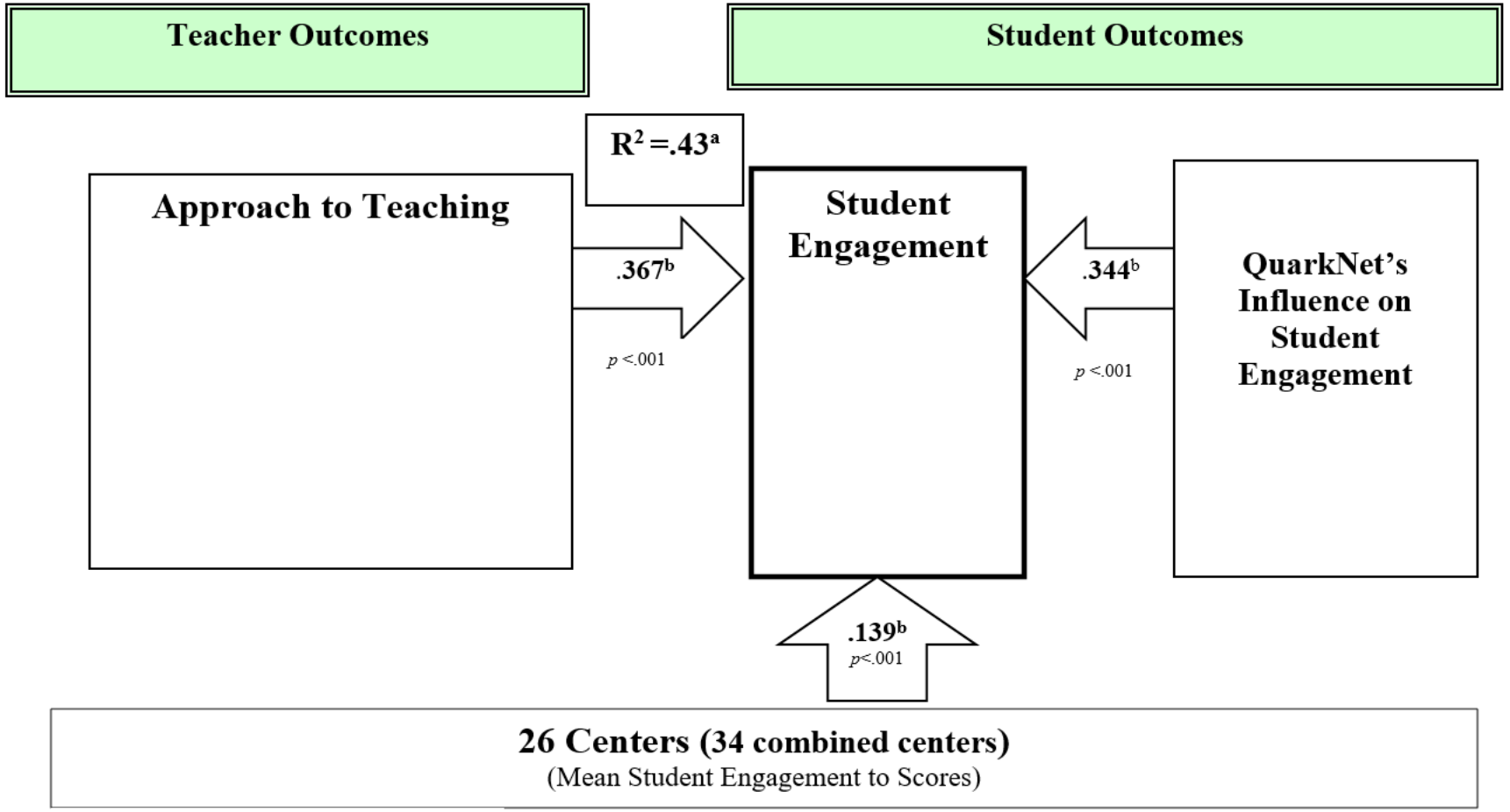
[b]Standardized beta weights

[c]Beta weight reduced to .069 in final analysis

Figure 9. The statistically positive relationship between exposure to Core Program Strategies, QuarkNet's Influence on Teacher, and Approach to Teaching as assessed using a hierarchical linear model.

Table 15 (con't.)
QuarkNet Evaluation: Summary of Major Efforts and Results

Evaluation Effort	Source(s) of Information	Highlighted Major Results
12. How QuarkNet Engagement is Related to Outcomes: QuarkNet Centers *Matter* (con't.)	• Full Teacher Survey • Hierarchical linear regression analyses that account for teachers nested in QuarkNet Centers. • Using scale scores to measure outcomes.	
b. Student Engagement (See Figure 11-12.)	• Scale Scores: Student Engagement, QuarkNet's Influence on Student Engagement, Approach to Teaching and Center-level Student Engagement Mean.	• This hierarchical linear regression analysis was based on 26 (34 combined) centers. The results of this analysis 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 [$F_{(3, 383)} = 94.43, p < .001$].
c. Long-Term Outcomes (See Figure 13.)	• Scale Scores: QuarkNet's Influence on Teaching, Student Engagement and Long-term Outcomes	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 [$F_{(3, 386)} = 66.64, p < .001$].
13. Qualitative Analyses: Center-level Portfolios A Narrative Picture of QuarkNet's Influence Compiled for 26 (34 combined) centers included in the quantitative analyses.	• Full Teacher Survey (open-ended questions) • Update Survey (open-ended questions) • Virtual workshop site visits by evaluator • Teacher Implementations Plans (workshop agendas/center annual report) • Examples of teachers' work • Examples of student work	Organized by center, portfolios are comprised of: • Teachers reported planned or actual use of QuarkNet content and materials in their classroom over time (based on survey responses). When available: • Implementation plans prepared by teachers or groups of teachers and posted on QuarkNet website are included. • Examples of teacher work (during workshops, science fairs, presentations at workshops/ professional conferences) are included. • Examples of student work are included.



Reliability Coefficients:

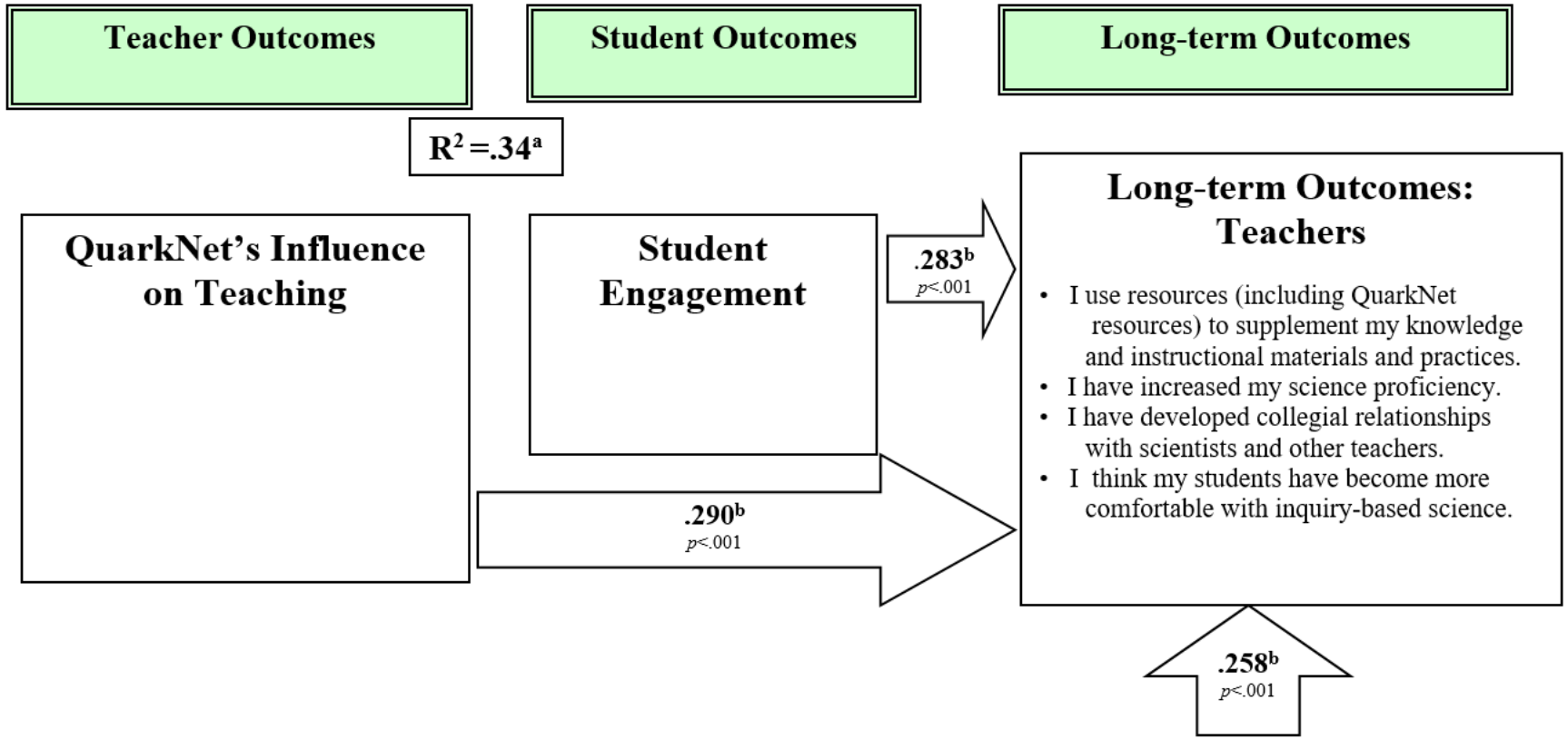
Approach to Teaching	0.87
Student Engagement (SE)	0.83
QN's Influence on SE	0.95

$F_{(3, 383)} = 94.43, p < .001$

[a]Percent variance explained

[b]Standardized beta weights

Figure 11. The statistically positive relationship between Approach to Teaching, QuarkNet's Influence on Student Engagement and Student Engagement as assessed using a hierarchical linear model.



Reliability Coefficients:

QN's Influence on Teaching	0.87
Student Engagement (SE)	0.83
Long-term Outcomes	0.81

$F_{(3, 386)} = 66.64, p < .001$

[a]Percent variance explained

[b]Standardized beta weights

Figure 13. The statistically positive relationship between QuarkNet's Influence on Approach to Teaching, Student Engagement and Long-term Outcomes as assessed using a hierarchical linear model.

Qualitative Analyses:
Center-level Portfolios
26 (34 combined) Centers

Center-level Portfolios

Each is posted on the QN Center's website

All contain a table that summarizes responses to open-ended questions by teachers over time.

Suggest a variety of ways in which QuarkNet content and materials are used in classrooms (and specific events such as science fairs, physics clubs, masterclasses).

Center-level Portfolios

Implementation plan examples from teachers:

Boston Area Center
Brookhaven National Lab
Catholic University of America
Johns Hopkins University
Oklahoma State University/University of Oklahoma
Virginia Tech University
University of Iowa/University of Iowa
University of Minnesota

Center-level Portfolios

Examples of work by teachers:

Rice University/University of Houston (coding projects)
University of Puerto Rico Mayagüez (coding projects)

Colorado State University (presentations at regional conference)
Kansas State University (center-level research project)
University of Illinois at Chicago (center-level data analysis project)
Fermilab (guest teachers at regional meeting analyze masterclass data)
Syracuse University (teachers drawing Feynman diagrams during workshop)

Center-level Portfolios

Examples of student work:

Boston Area (data collected by students during a masterclass)
Virginia Center (data collected by students during a masterclass)
Idaho State University (student poster at local science fair)
Lawrence Berkeley National Lab (student presentation during workshop)
University of Minnesota (former student co-author of published paper)
University of Illinois at Chicago (student presentations at national conference)
University of New Mexico (particle deck sorting activity – classroom work)

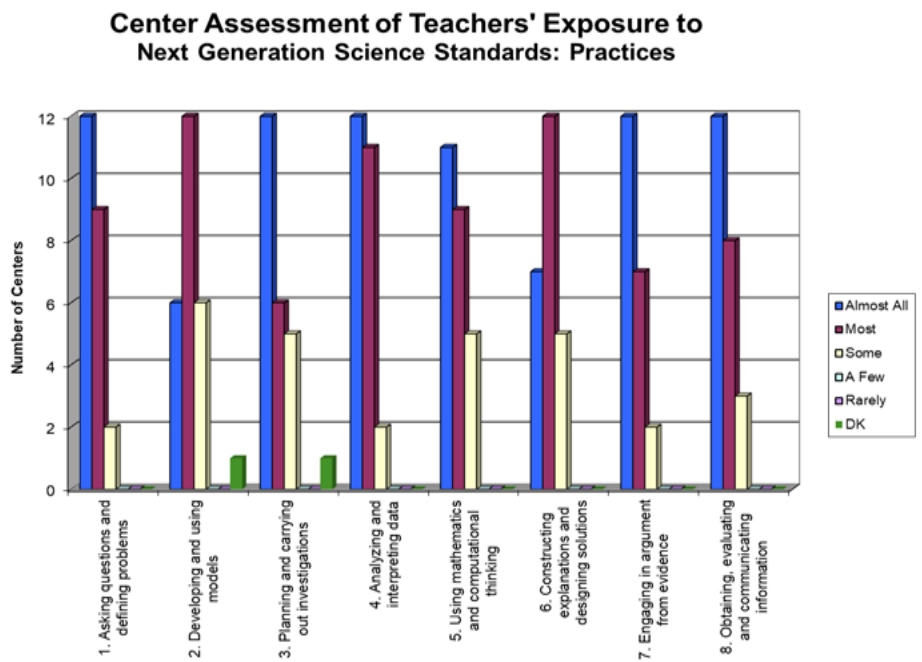
Table 15 (con't.)
QuarkNet Evaluation: Summary of Major Efforts and Results

Evaluation Effort	Source(s) of Information	Highlighted Major Results
14. Center-level Outcomes and Effective Practices (See Figure Set 14 for comparisons of designed vs. implemented and teacher-level and center-level responses.)	• Center Feedback Template • Effective Practices (M.J. Young & Associates (2017, September). *QuarkNet: Matrix of Effective Practices*	• Center-level responses from Center Feedback Templates indicate that QuarkNet teachers engaged in NGSS Science Practices as part of their work-shop engagement; and this experience has a noted influence on teachers related to these practices. • Comparisons suggest good agreement on select responses by individual QuarkNet teachers and QuarkNet centers [26 (34 combined) centers]. • Results suggest good alignment of centers to meet the criterion of each of 10 effective practices. • Offers a suggestion of program sustainability (i.e., what is being sustained).
15. Getting the Word Out Compiled by K. Cecire and S. Wood	• https://quarknet.org/content/publications-presentations-and-posters-sept-2018-sept-2023 • Publications, Presentations, and Posters June 2023-Present | QuarkNet	• As of the 2023 program year (Sept), QuarkNet has posted a total of 72 presentations, posters, and publications by staff, teachers and/or students. • From June 203 to present, an additional 35 presentations, posters, and publications by staff, teachers and/or students have been posted.
16. QuarkNet Success Stories: Case Studies	• Testimonials • Interviews with select staff, teachers and former students • Emails from staff about former students • Evaluation Team | QuarkNet	• In more detail as how QuarkNet has influenced teachers, students as well as its staff, a series of two supplemental reports were created in support of these quantitative and qualitative analyses • Each vignette prepared with the active participation of the individual highlighted. • The first report highlights individuals from four QuarkNet centers. The second report highlights individuals from one QuarkNet center. • Staff, teacher and student work examples are proffered including publications, and presentations.
17. Program and Evaluation Recommendations	• Culmination of information sources contained in this evaluation	• A total of 10 program recommendations and • 10 evaluation recommendations are proffered.

Center-level Feedback Templates

Comparing Center and Teacher Responses

Effective Practices/Success Factors


Center Assessment of Teachers' Exposure to
Next Generation Science Standards: Practices
Number of Centers
0
2
4
6
8
10
12
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating and communicating information
Almost All
Most
Some
A Few
Rarely
DK

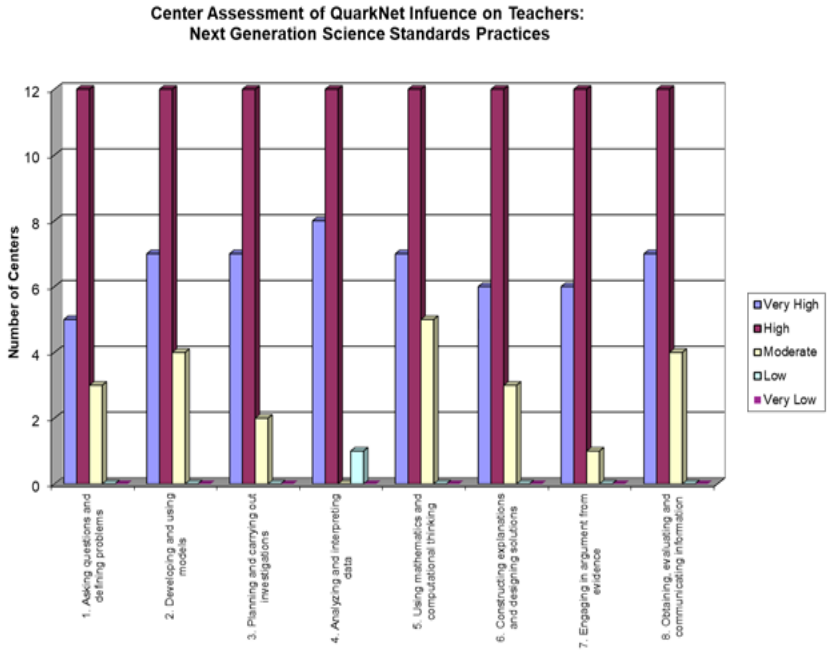

Center Assessment of QuarkNet Infuence on Teachers:
Next Generation Science Standards Practices
Number of Centers
0
2
4
6
8
10
12
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating and communicating information
Very High
High
Moderate
Low
Very Low

Table 13
Comparison of Center-level[a] and Individual Teacher[b] Responses

Program Engagement Opportunities	Center: Engage Teachers as Active Learners, as Students[a]	Teachers: QuarkNet provides opportunities for teachers to engage as an active learner, as a student[b]	Center: QuarkNet's Influence on Teachers (on this behavior)[a]
Teachers engage as active learners, as students	*Almost all* Teachers 20/25 centers	79% of teachers reported opportunities as *Excellent*	Rated as 14/25 centers *High* 11/25 *Very High*
Teachers interact with Mentor(s) and/or	*Almost all* Teachers 18/25 centers	81% of teachers reported opportunities as *Excellent*	Rated as 16/25 centers *Very High* 6/25 centers *High* 22/25 *Very High/High*
Other teachers	22/25 centers		12/25 centers *Very High* 9/25 centers *High* 21/25 center *Very High/High*
Form lasting collegial relationships	*Almost all* Teachers 12/25 centers *Most* Teachers 7/25 centers *Almost all/Most* Teachers 19/25	63% of teachers reported opportunities to form collegial relationships with scientists/teachers as *Excellent* 71% of teachers reported opportunities to building a local learning environment as *Excellent*	Rated as 12/24 centers *Very High* 9/24 centers *High* 19/24 centers *Very High/High*

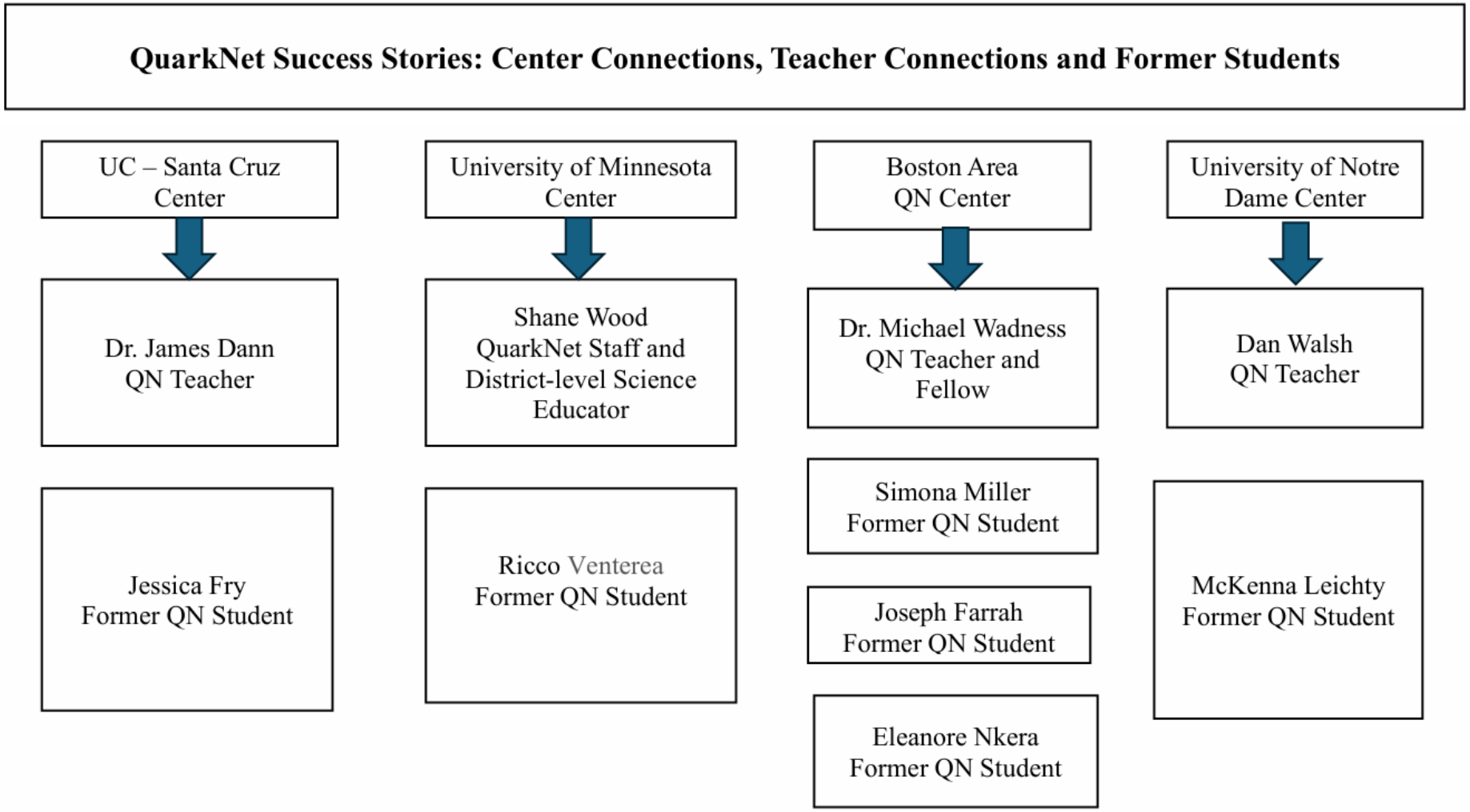
[a]Based on 25 (33 combined) centers.
[b]Based on teacher survey data from 2019-2024 program years (for teachers who answered this question).

Getting the Word Out

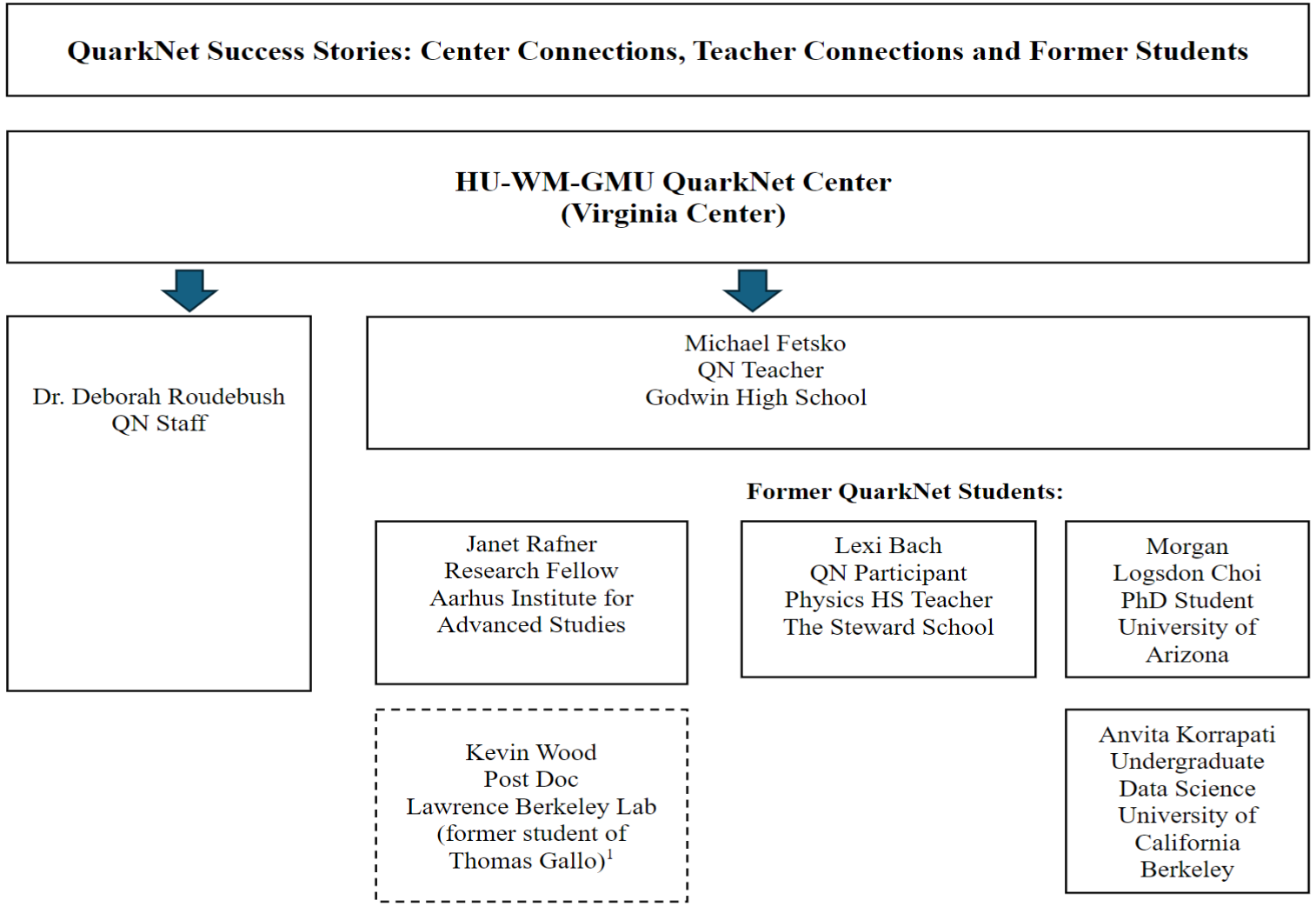
2018-2023 72 Publications, presentations, and posters
Publications, Presentations, and Posters 2019-2023 | QuarkNet

June 2023 Additional 35 works and growing
Publications, Presentations, and Posters June 2023-Present | QuarkNet

Success Stories:
Select Case Studies



Success Stories Report I [Supplement I Final | QuarkNet]



[1]Thomas Gallo (currently at Freeman High School in Henrico VA) and Michael Fetsko together conducted QuarkNet Masterclasses and laboratory tours when they both taught at Godwin High School at the time Kevin was in high school.

Success Stories Report I [Supplement I Final | QuarkNet]

Program and Evaluation Recommendations

Bringing into the Evaluation

Next Steps:

Acknowledge/Review Additional Data/Sources

Cosmic Ray studies (data/examples) ✓

Masterclasses (focus on students' collection of data) ✓

Professional Presentations (by QN staff, teachers, and students) ✓

Cosmic Watches – will include as this becomes more established in program