Center-Level Portfolio: Boston Area

The following table, proposed implementation plans by participating teachers, and when available other examples are intended to provide an overall narrative about how and in what ways program participation has influenced teachers in using QuarkNet content and materials in their classrooms (and in-after class events). The value of these qualitative reviews is to expand on the instructional practices measured quantitatively via Teacher Survey responses to specific sets of questions/self-reported by teachers providing narrative examples of implemented or planned instructional practices in teachers' classrooms and in schools. This evaluation approach is consistent with the use of *authentic assessment* to evaluate performance, "teaching for under-standing and application rather than for rote recall" (Darling-Hammond & Snyder, 2000, p. 523).

In keeping with Darling-Hammond, Hyler and Gardner (2017), we do not naively expect a single workshop (or event) to have a measurable impact on teachers' knowledge and subsequent classroom implementation. A characteristic of effective professional development is a program of sustained duration, providing "multiple opportunities for teachers to engage in learning around a single set of concepts or practices; that is rigorous and cumulative" (Darling-Hammond, et al., 2017, p. 15). As such, the table summarizes responses by teachers over the course of several program years and likely several QuarkNet programs and/or events.

These responses come from the Teacher Survey (either the full or update version) where each row represents the responses to open-ended questions from the same teacher over time. Also, each row starts with the original responses to the first time a teacher completes his/her full teacher. If a particular box in the table is blank, it likely means that that teacher did not participate in an event for that program year (or, the center may not have had a major event that year). The table provides the essence of these responses; a given response, as presented, may be a direct quote, a paraphrase, or lightly edited; the intent is to convey the overall idea or its essence from that particular teacher.

Because these are responses to open-ended questions, teachers are free (and encouraged) to provide information that he or she thinks most relevant. Each highlighted response is intentionally anonymously to respect the principles of collecting evaluation data (*Guiding Principles for Evaluators*, American Evaluation Association) and to help encourage teachers to respond frankly to these questions. If a reader is familiar with a given center, it may be possible to "reverse engineer" the identify of a particular teacher. We encourage readers to respect this anonymity. At various times, we may have identified a given teacher by name and/or school; when this happens the written approval of that teacher has been obtained. It is also important to note that the full breath of a response by a given teacher may not be fully articulated in this table. For example, responses related to how QuarkNet may have advanced the knowledge of a given teacher or bolstered a collegial network among participants are likely discussed elsewhere in subsequent evaluation reports.

The table is followed by examples of implementation plans, and at times teacher presentations and student presentations when available. The intent of providing these examples is to deepen the narrative as to what and how teachers have planned (and have used) QuarkNet content and materials in their classrooms and in-after class events (e.g., Physics Club). Examples from Annual Center annual reports may be highlighted as well.

Table
Self-reported Use of Data Activities Portfolio Activities: Based on Responses from the Full Survey and then Responses from the Update Survey in Subsequent Years **Boston Area Center**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
Boston Area	2019	2020	2021	2022	2024
	I have used the deck of cards (subatomic particles) with students to prepare for the masterclass. There is a nice variety of activities and they are teacher friendly (easy to pick up and try). This is the strongest aspect of QuarkNet that I've experienced. It opens my eyes to a lot of current events in the world of physics and what the future holds in the research world I often learn a lot at QuarkNet events and my passion for physics is always emboldened by QuarkNet. I would like to focus more on how to specifically integrate particle physics into a high school classroom. At QuarkNet meetings, we go over lots of advanced material which is great, but making that attainable for a high school student is very challenging.	I mostly use these tools in my after-school club 'Theoretical Physics Club'. Students present topics and activities on a different subject each week. Examples: Rolling for Rutherford; Dice Decay Probability	The physics classes I teach do not end up reaching most topics covered by QuarkNet experiences, so I plan to use these mostly for the after-school science club that I will be running. Examples: Rolling with Rutherford; Mass of a Penny; Step Up Physics	Used activities for my science club very frequently. A few times a year I will incorporate into my Honors Physics curriculum during conservation of momentum energy units. Examples: Rolling with Rutherford, Mean Lifetime, STEP UP activities.	Used the printout particle puzzle pieces to help prepare students in physics club for the masterclass. They contain novel strategies for drawing conclusions from data that most students in high school don't experience elsewhere.
	N/A			I expect the information on fusion this summer will be very helpful for my AP as I cover modern physics with my students at the beginning of the year (while they are learning calculus in math classes). I am not familiar with method of accessing DAP. I think that QuarkNet is important in keeping physics teachers up to date on current research and developments.	This summer's QuarkNet activity was particularly useful to me. Every year I begin my AP Physics class by covering topics in Relativity so that students have time to learn some calculus in their math classes before we use it in Physics. Because of our focus on Relativity and related topics, I feel like I have a number of new resources which should make my coverage of the topic more engaging for students. [Not sure... I am not actually familiar with the DAP.] The importance of this program, to a large extent, is to keep teachers ahead of the curve, and make sure we know where students might head in post secondary studies in physics, and thus provide them the foundation they need.

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Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
Boston Area	2019	2020	2021	2022	2024
	I'm not sure what Data Activities Portfolio is, but I use the cosmic ray detectors in my classes and I have my students do the CMS data analysis on CIMA.			Cosmic ray experiments in all physic classes. Masterclass CMS analysis in all physics classes. Masterclass attendances once it resumes. Teaching particle physics and nuclear physics in all classes. Students do cosmic ray experiments outside of class during the school year and during the summer. Examples: Shuffling the Particle Deck, Calculating Z Mass and Top Quark Mass, Histograms; Uncertainty.	I do muon experiments and CMS Masterclass analysis in my Physics and Honors Physics classes and with our school's STEM Club. Examples: Quark workbench, particle deck, histograms, Z mass, top mass, mean lifetime (those are the most recent but I've used more in the past and will in the future).
			Coding Camp (Google Colab Notebooks), Standard Model. Have not used DAP materials yet, I was remote the entire school year.		
	The Rutherford activity is used at all levels. It is engaging, challenging and gives great insight into indirect observations.				
	I used a variation of the Mean Lifetime Part 1: Dice Activity with my Physics students to explore the idea of radioactive decay. I used (and still use) the Calculate the Z Mass and Top Quark Mass activities with the Advanced Topics students. I used Rolling with Rutherford and Quark Workbench activities to prepare students for participation in Particle Physics Masterclasses at Northeastern University.	I incorporated QuarkNet-related exercises in my Advanced Physic Topics class and brought students in that course and in my Honors Physics course to Particle Physics Masterclasses. Examples: Calculate the Z Mass, Calculate the Top Quark Mass, Mean Lifetime: (1) Dice) and (2) Muons	I frequently used QuarkNet materials and ideas in my physics teaching, particularly with my Advanced Topics in Physics class. I am currently retired. Examples: Rolling with Rutherford, Calculate the Z Mass, Calculate the Top Quark Mass, and several others. I have continued to host and promote QuarkNet meetings for the Boston group in order to share.	I used QuarkNet materials for masterclass preparation and for students in the Particle Physics portion of my Advanced Topics in physics class. Examples: : Rolling with Rutherford, Calculate the Z Mass, Calculate the Top Quark Mass,	
	The Rutherford activity is used at all levels. It is engaging, challenging and gives insight into indirect observations.				

Table (con't.)
Self-reported Use of Data Activities Portfolio Activities: Based on Responses from the Full Survey and then Responses from the Update Survey in Subsequent Years **Boston Area Center**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
Boston Area	2019	2020	2021	2022	2023	2024
	QuarkNet has had a substantial impact on my understanding of particle physics and how scientists conduct experiments and use data. The impact on my classroom has been moderated the limits of time and curriculum.				Rolling Rutherford – probability and representation of data, Mass of Top Quark – momentum and energy, particle physics	

Note: Each row presents responses from the same individual teacher from a given center. Empty table cells indicate that the teacher did not participate in QuarkNet in that subsequent program year(s). Or, less likely did not complete the Update Survey; or did not answer specific questions about the use of DAP activities in their classrooms.

Table (con't.)
Self-reported Use of Data Activities Portfolio Activities: Based on Responses from the Full Survey and then Responses from the Update Survey in Subsequent Years **Boston Area Center**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year
Boston Area	2021	2022	2023
	Top quark, Alas Master class - both contribute to how data is used to understand nature, understanding role of error in experiment and excellent applications of conservation principles		
		QuarkNet has deepen my understanding of modern physics, but, to date this hasn't been a specific focus of my classes. This material mostly comes into the classroom during "off topic" class discussions. A student asks a question, then my answer spawns another student question, then we end up talking about Cosmic Rays or something else like that. I haven't used any of the Data Activities Portfolio, and that has more to do with me than the activities. I think I'll experiment with them a bit this semester.	
	I have not had the opportunity to use these yet.		
	I haven't used them yet (I'm new to QuarkNet) so I wouldn't recommend something that I haven't tried out.		
	Rolling with Rutherford great for using probability trials to determine real data, the Missing Mass activity (great for vector addition	Masterclass, using finding of Z mass from vectors. Examples: Rolling with Rutherford and Calculating the Mass of Z.	
	Program Year (Year of Full Survey)	Program Year (Year of Full Survey)	
	2023	2024	
	Pretty new to QuarkNet. I am an mechanical engineer by education. The physics of things BIG and the physics of things SMALL is new to me.	I just wrote a lesson using a Mean Lifetime that I will use this coming year. The data portfolio (and all QuarkNet particle related material) is not sufficiently covered in most teacher preparation programs.	
	New to QuarkNet. This will be helpful for the modern physics class I will teach this coming year.		

Note: Each row presents responses from the same individual teacher from a given center. Empty table cells indicate that the teacher did not participate in QuarkNet in that subsequent program year(s). Or, less likely did not complete the Update Survey; or did not answer specific questions about the use of DAP activities in their classrooms.

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Boston Area	2021	2022	2023	2024
	Momentum Conservation top quark activity (in class). It's a bit high-level for some of the courses but it's a great way to incorporate actual data into class and to gain some relevance.	Fusion Materials from today will help with MA frameworks for intro physics. Examples: Penny Mass, Quark Workbench, Mapping Poles.	Top Quark (momentum conservation); Rolling for Rutherford ; diffraction demonstration (from summer) workshop.	Top quark (momentum) Quark workbench (intro standard model when time allows). This is a great group to be a part of. It allows me to continue learning with other educators and gives me materials to enrich curriculum for my students. Thanks.
	I used the data from bootcamp when teaching conservation laws. It is good to have data and information related to modern physics research	Rolling with Rutherford, collision data		Collision data in the Momentum unit

The following pages provide examples of implementation plans proposed by participating teachers during the 2023 summer workshop. This is followed by an example of data analyzed during a Masterclass also held in 2023.

Boston Center Implementation Plans

Thu 10 Aug 2023

Teacher #1

I would like to use something like the WW activity for introductory physics (grade 10) - likely with a more everyday example like flipping coins - to reinforce the idea of uncertainty in measurement. This would also be a good opportunity to introduce histograms and half width to provide students with a more analytical approach to uncertainty than I usually use at the introductory level. This would be an activity of the first quarter of the year.

If I can get to it - I hope to incorporate enough particle physics into AP Physics (which is a second year grade 12 physics class) to use Top Quark or Z mass activity. This is an activity to show how experiments to find new particles are performed - and connect between the classical conservation laws and particle physics. This would be incorporated during the year (modern physics Fridays) or in the final weeks between the AP test and end of the school year.

T#2 - 9th Grade Physics

Want to include standard model content, but do not want to introduce new zones for student confusion or muddle required content for MCAS.

Most logical place for inclusion is during unit on atom, subatomic particles, and radioactivity (January/February)

- Short unit, space for additional activities whether simple introduction or more in-depth projects.

Option #1: Shuffling the Particle Deck

- Simple activity to move beyond proton/neutron/electrons, allows students to begin exploring the wider world of particle physics without getting lost down any particular complex rabbit holes.

Option #2: Engineering Project

- Next year I am teaching a project based physics course, so it may make sense to expand this topic into a larger project. Building a cloud chamber could tie into existing standards with radioactivity, and could also enable explorations of new standard model content such as with cosmic rays.

Teacher #3

Our modern physics course runs in the spring semester. Probably around March, after some work on the standard model, I plan to have students work on measurement and uncertainty. We will probably use a sequence similar to our current workshop, starting with dice or coins to build statistical concepts, then analyzing measurements of, perhaps, the W mass and discussing the resulting statistics.

The Data Activities Portal is new to me, I expect I'll find something additional there to apply in class.

Teacher #4 (also a Fellow)

I want to use more halfwidth activities to help students understand statistical uncertainty.

I'm going to use either coin flips or dice in the beginning of the year.

Throughout the year (once a month?) I would like to use a different activity in the new physics workshop to expose students to what some of the big questions that are going on today.

Although not in the data portfolio (yet), I'm working on developing a handful of data-based activities that provide an introduction to ideas in quantum mechanics.

In addition, I plan on doing my usual participation in wwdd, masterclass (and prep), cosmic ray detector, and several activities from the data portfolio

Teacher #5

- Use “Rolling for Rutherford” lesson early in the year as students are transferring from chemistry to physics studies. Also as a warm up for data collection and analysis techniques
- With AP physics 1, some data analysis can be done during the momentum unit with data sets from particle colliders where momentum must remain conserved in two dimensions (x+y). This would give students a direct application of the law and also some experience as to what professional particle physicists are currently investigating
- 3d printed “quark workbench” for science club

Student Work CMS Masterclass
March 11, 2023

Below is an example of histograms created by data collected and analyzed during a Particle Physics Masterclass held on March 11, 2023 at Northeastern University. A total of 31 high schools and five QuarkNet teachers from Massachusetts, Rhode Island, and Vermont. (As described in the Boston QuarkNet Center 2022-2023 Annual Report.) Students worked in groups of two to collect the data graphed below.

Masterclass: FNAL-11Mar2023A
location: Boston2023