Center-Level Portfolio: Brookhaven National Laboratory Stony Brook University

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 understanding 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 anonymous 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 **Brookhaven National Laboratory Center**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
Brookhaven National Laboratory	2019	2020	2021	2022	2023	2024
	As this is my first experience, I look forward to using some of these resources in the upcoming year.					I am excited to bring more information on Neutrinos into my modern class. The idea of the quantum cards, and the puzzle pieces for quarks will also be a great tool to help them to understand. Finally, I am going to work on learning more coding so I can bring that skill to my students when analyzing data. Quark Workbench, Shuffling the Particle Deck, probably the Step Up lessons as I am interested in that, and eventually the Research Using Coding. I loved hearing from the scientists talking about their work and bringing us to a deeper level of understanding. In addition the two teachers who lead our workshop did a great job of modelling teaching. It is really awesome to have workshops with a focus on physics curriculum like this.
	It is a way to expose students to real science.					
	Minerva seems like it would be the most helpful in teaching. I liked how MInerva talked about how the neutron changed into a proton and a neutrino. Masterclass talks about the Z boson which is more abstract than the neutrino. The activities seem to align with our curriculum(s).					
	I am unaware of the Data Activities Portfolio					
	Not familiar with it		Info on the LHC is useful for discussing particle accelerators. Details about the Standard Model go well above New York State curriculum requirements, but adding in that info is more complete. (retired) This is a great program to improve physics teaching. It is too bad more people do not participate.			

Table (con't.)
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Brookhaven National Laboratory	2019	2020	2021	2022	2023	2024
	I will be looking through the list and using some activities next year. It looks interactive and informational.	Data Camp. This year we worked on Juypter Notebooks. I will use this as a springboard to introduce Python in the engineering course I teach. Additionally, I created an activity that can be done in the classroom. Will use - Dice histograms and probability to introduce Python and histograms Have used - Rolling with Rutherford	This past year my physics students participated in a LHC masterclass and Big analysis of muons. I used rolling with the Higgs as virtual lab. I will use the graphs of motion notebooks in AP Physics 1. Examples: Rolling with the Higgs I plan to use a few more but I'm not sure which.	I would like to use a cosmic ray detector with my science research students. Examples: Quark Workbench, Shuffling the particle deck, Rolling with Rutherford	The CERN Summer workshop and the coding camps have been helpful. The length of the CERN program allowed for in-depth exploration and S'cool Lab was a highlight. I've started using coding in my classes Examples: Rolling with Rutherford, Quark Workbench, and Shuffling the Particle Deck are the activities I use at the start of the modern physics unit. They help the students visualize what they can't see and become familiar with the unusual names and properties of particles in the Standard Model. I recommend it because there are various activities at different levels that come with easy-to-follow implementation instructions..	
	The workshop enables me to bring real data analysis techniques to my students. I think actually having students perform data analysis would make particle physics research more tangible to students.		In the past I had used scintillator panels and discriminator boards to describe the behavior of Cosmic Rays and connect them to other vents, like lightning strokes.. (retired)			
	ATLAS Masterclass. I bring students every year. They learn a lot and get a lot out of the introduction to particle physics, the masterclass exercise, and the field trip to BNL.	I plan to incorporate some of the Python coding from this week's workshop in my classes. Specifically, I would like to introduce Python coding during kinematics, then hopefully follow up with more Python. I may use "Make it round the bend".	This workshop was valuable in showing me how I could introduce simple Python coding exercises in class, to support curricular material as well as introduce students to coding.	I may use "Make it round the bend" Examples: Masterclass, lifetime, STEP UP. I really enjoyed QuarkNet. Through the program and also through discussions during the program I was able to imagine and create lessons that help my students lead more authentic investigations.		

Table (con't.)
Portfolio Activities: Based on Responses from the Full Survey
and then Responses from the Update Survey in Subsequent Years **Brookhaven National Laboratory Center**

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Brookhaven National Laboratory	2019	2020	2021	2022	2023	2024
	My first workshop. I got a lot out of the Teacher Workshop that I would like to implement in the new Conceptual Physics course my school is launching this fall! N/A (but I plan to teach some of the topics in my physics classes!) Good emphasis of conceptual physics, and it gives you a good feel for what is going on in physics today. I now have a better idea of how to implement 21st century skills in my classes! I am so grateful for the opportunity to attend this QuarkNet workshop at BNL! My future plans will definitely include attending more of these workshops, as I am always interested in furthering my knowledge of physics!		From this activity, I want to pull in the coding-specific lesson design to my physics classes. I'd like to target on-level physics students with coding-based activities. I was planning to use some of the activities in the last 2 school years, but the pandemic unfortunately made it much more difficult for me to get through even the required curriculum with my students.	This coming school year, I will be teaching Science Research for 9th graders in addition to Regents and Conceptual Physics. I plan to use the QuarkNet elabs in my Science Research class to help students learn how to conduct their own experiments and think critically. I haven't used any of the activities yet as my curricula did not allow enough time to dedicate to the activities. I plan to use them more often as I will be teaching Science Research next school year.		Shuffling the Particle Deck

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 **Brookhaven National Laboratory Center**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
Brookhaven National Laboratory	2021	2022	2023	2024
	The Practical Code for Physics Class would definitely be the most helpful, in order to better visualize, interpret, and model motion.			
	Rolling with Rutherford Shuffling the Particle Deck Quark Workbench Atlas Z-path Masterclass. My students really enjoyed the material! In addition to being fun, well-designed, and easy to implement in the classroom, QuarkNet activities were absolutely instrumental in making my class more interactive and teach the content using an inquiry-based approach. I am new to QuarkNet, but I find this group truly inspirational! QuarkNet's resources and shared teaching experiences are helping me run my class the way I have always wanted. Through QuarkNet I can now bring my prior academic research (LHC-Atlas) and work (programming) experience to my students more effectively and in a more tangible way. I am extremely grateful to QuarkNet for that!			

Table (con't.)
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Brookhaven National Laboratory	2023	2024
	W2D2 was very helpful in introducing the student to CERN and the process of analyzing data. Neutrino MC will be helpful in broadening their understanding of particle physics and its importance. Rolling with Rutherford was used as an introduction to the concept of the atom and a reinforced the idea that indirect observations are valid and helpful. The instructional materials can be adapted to many levels of students to reinforce many modern physics topics. My experience with QuarkNet has been positive and helped me grow as an educator.	I would like to participate in WWDD and hopefully a masterclass next year. I am interested in several activities that will be useful next school year. Examples: Rolling with Rutherford Energy, Momentum & Mass Top Quark, Quark work bench.
	I have only attended the one workshop, but I think it will be helpful in my teaching. Introducing coding to my students with real data and giving deeper, more current information on subatomic particles will be helpful in piquing their interest and giving them a greater understanding. I have not used these activities yet, as I am new to the program. QuarkNet has given me the opportunity to bring more relevant science into my classroom - and I feel as though I have a concrete plan to do so.	I am going to implement the Rolling with Rutherford, the quark workbench, and the calculate the top mass into the classroom. I will also be adding a Modern Monday intro to talk more about modern during the school year. Examples: Rolling with Rutherford, Finding the mass of the top quark, and quark workbench
	NOvA Masterclass. I will be able to bring this information to my students and work toward participating in World Wide Data Day and teaching introductory particle physics in a more interesting way. Using the Quark workbench and rolling with Rutherford will especially help make particle physics more accessible to students.	
	Rolling with Rutherford: great introduction to uncertainty. Easy to implement, good physics. It would be nice if the activities related more closely to the NY or AP curriculum.	
	I have not used them.	
	ATLAS MasterClass - some students like to learn about topics that are outside the curriculum. Rolling with Rutherford: great introduction to uncertainty It would be nice if the activities related more closely to the NY or AP curriculum.	

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Brookhaven National Laboratory	2023	2024
	I hope to incorporate the muon and neutrino labs in my next physics class. The activities give students a feel for what real scientists do. The emphasis on collection and analysis of data along with the need for collaboration is excellent. The workshops that I have attended thus far have been outstanding in how they have incorporated the strategies. The workshops have provided a good general introduction to big particle physics ideas, and they have shown how those ideas have been generated and refined through data collection and analysis. QuarkNet has been incredibly helpful. I look forward to incorporating QuarkNet activities in my classroom, and I am making definite plans to bring students to Master Class.	
	Boot Camp was great for giving me a much better grasp of particle physics and the physics and technology involved in particle detectors. I have used what I learned there to share with students about ne N/A - but I wish that I were more familiar with them developments in physics and how physicists investigate such things. I'd love to spend a small amount of time at a future summer workshop exploring what is available in the Data Activities, guided by a QuarkNet expert. QuarkNet connects me to cutting edge physics and practicing physicists in a way that nothing else in my professional life does. It is invaluable. The student-run Cosmic Ray Club at my school owes its existence to QuarkNet entirely.	
	Program Year (Year of Full Survey)	
	2024	
	I will know more when I try them. Quark geometry and Atlas vector sum activity. I have not used QuarkNet in the classroom yet because I'm new to it.	
	Shuffling the Particle Deck.	
	CERN Summer Program. I am able to share first hand experiences with my students. They are very interested in the LHC and like to hear about the environment where cutting edge physics is occurring. I have used the Hypatia program and data set the most often with students. It is very helpful for developing critical thinking and decision making skills. Recommend. The portfolio is well organized. This makes it easier to use. The fact that Hypatia has different versions and can be used on multiple platforms makes it easier to deploy in the school. Recommend. The portfolio is well organized. This makes it easier to use. That fact that Hypatia has different versions and can be used on multiple platforms make it easier to deploy in the school.	
	New to program.	

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.

The next several pages provides examples of proposed implementation plans offered by participating teachers who participated in a summer workshop during the summer of 2024.

QuarkNet Implementation Plans at BNL

Friday 28 June 2024

Teacher #1

Regents Physics, 11&12, Modern Physics Unit

I will use the quarks puzzle app to allow students to create their own baryons and masons and explore the different types of combinations that work and the ones that don’t. I would also encourage them to come up with the rules that the standard model abides by when deciding which particles can go together.

This activity will lead to a discussion about charge, flavor, spin, etc.

Teacher #2

Class.Course, Grade Level, When to implement

Description

Regents and AP1

Introduce some of this material as an introduction of vectors and determination of equilibrants.

Second and revisit the these vector diagrams in terms of conservation of momentum

Along with introduction and discussion of modern physics.

Teacher #3

Class: Intro to Research Skills & Statistics

Grade Level: 9

When to Implement: after teaching mean/median/mode and basic graphing skills

Students will use HYPATIA Online to figure out the mass of the Z-boson. Once all data is gathered, they will create a graph on paper first to practice graphing skills. Then, students will try to look for patterns in the data, if any, and practice calculating mean, median, and mode based off their data. They will then describe the significance of the peaks on the graph.

Teacher #4

Regents Physics

11/12th grade

At then end of the momentum unit

Description

Finding the mass of a Z Bozon activity

After teaching Momentum, and specifically conservation of momentum using collisions of larger masses like cars and billiard balls, I would introduce briefly the idea of subatomic collisions and how when two protons collide a z bozon is briefly created and then they change into an electron and a positron. I would have the students demonstrate the collision activity, and then relate it to the cern data and have students measure the angles and create a momentum problem to calculate the mass of the z Bozon by measuring the muon angles.

Teacher #5

AP Physics 1: 11-12th grade: Early in the year

Description: Energy, Momentum & Mass

Allows students to practice linearization in a real world application.

Introduces the concept of energy-mass equivalence and momentum and practices using graphs to determine relationships between variables.

Teacher #6

Regents physics, 11-12 grades, Unit: Motion in 2D

Case of missing neutrino to practice graphic vector addition and discuss equilibrant.

Revisit with top quark mass during conservation of energy and conservation of momentum.

Teacher #7

AP Physics C, Grade 12, Unit: Nature of Science

Use real world examples and data to show how results can be inferred from data. Most of my AP C students are usually coregistered in AP Statistics. Discussion of how data is handled, errors, and the importance of sample size would be included. The Hypatia program asks students to think critically about what they see and encourages them to decide how to categorize particles based sometimes on limited information.

Teacher #8

Regents Physics, grade 11-12.

Rutherford Experiment Beginning of the year

Quark Workbench when introducing the standard model

Calculate Top Quark Mass: Vector addition depending on students, with vector addition or as review during modern