Center-Level Portfolio: Johns Hopkins 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 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 **Johns Hopkins University**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
Johns Hopkins University	2019	2020	2021	2022	2023
	Great real-world data sets, 'hard' science research.				
	Nothing really compares to CERN, but the master classes have been helpful as well. They provide insight into how to approach student questions on a deeper level. Rolling with Rutherford. They are valuable and well written. QuarkNet has influenced thousands of students through the teachers in the program.	I am going to consider new physics principles, such as pulsars and microwave telescopes. Example: Rolling with Rutherford. It is an enriching experience.	I will use some of the new cosmology lessons with my Astronomy class. I teach them about the Big Bang, black body radiation and the HR diagram. I will use DAP activities as well as conservation tools. Examples: Signal and noise 1, signal and noise 2, and histograms. Rolling with Rutherford. It’s been wonderful and I appreciate having so many colleagues who work on similar projects (and who I can ask for help).		
	Data camp - great opportunity to collaborate with physics teachers around the country. Rolling with Rutherford, calculating energy and momentum, quark puzzle activity	Conservation laws, the standard model. Examples: Rolling with Rutherford, conservation of energy and momentum, quark model	I plan to use the blackbody radiation activity and the Hubble's law activity as culminating activities for my introductory physics class. Examples: Cosmic microwaves, Hubble's law	Rolling with Rutherford, calculating energy and momentum, quark puzzle activity	

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 **Johns Hopkins University**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
Johns Hopkins University	2019	2020	2021	2022	2023	2024
	Data Camp because I feel like we actually learned physics concepts we had not known or understood and learned new skills. I think Rolling for Rutherford is an easy way for them to understand the experiment through experience and inquiry. I would adapt it to more than just rolling a marble at dice. I would also have them roll a marble at a mystery shape underneath a piece of cardboard and predict what the shape was. There is a wide variety of lessons and activities there that can be applied to multiple subjects. I think there are opportunities to engage as an active learner. However, this is not always the case. Last summer, I felt like much of what we did was passive in the sense that we had a lot of speakers. Don't get me wrong, I love listening to talks and even have a backlog of science podcasts on my phone, but there were just too many and not enough active learning. Also, when put in groups at various QuarkNet events, you can get paired with people who are at a significantly different level than you. That makes for some good discussion, but ultimately leads to less learning if you are the one who is at the higher level of understanding. I think it is worth considering having QuarkNet for non-physics teachers and QuarkNet for physics teachers. It is the best professional development program I have done.	This year, we did more related to online learning because of the circumstances related to the pandemic. Having content that can be used virtually, like the QuarkNet e-Labs, will be super useful. Examples: Rolling with Rutherford; The one where you use the detector information. Because we met virtually this year, we could not have hands on workshop activities in the afternoon.	Next year I will be teaching astronomy in addition to physics, so the cosmology topics and activities that we just happen to focus on this year will be particularly helpful. The new ones I will incorporate are: Mapping the Poles and Particle Transformation. I look forward to this week every year. For most workshops, getting one thing out of it after a whole week of work is generally a sign of a productive workshop.	I was doing Coding Camp 1. The obvious thing from this experience is that I would incorporate is the coding in Python. I will have some introductory coding activities, but ultimately I envision it as a tool that they will be using to help them with labs, homework or projects. Examples : Rolling for Rutherford Histogram Basics Quark Workbench This Coding Camp 1 has been great. It was just the right amount of student hat and teacher hat time. I learned a lot, but I also got a lot of time to explore. I also like how we had time to develop a complete lesson and test it out with other teachers acting as the students on the final day. That feedback was great.		(1.) Rolling for Rutherford (2.) Dice, Histograms, and Probability (3.) Histogram: The Basics (4.) All the coding notebooks. I would recommend the Data Activities Portfolio and QuarkNet to everyone because it is free, and it has changed my content and pedagogical knowledge better than any other PD.

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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 **Johns Hopkins University**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
Johns Hopkins University	2019	2020	2021	2022	2023	2025
	Data Camp has been excellent. Learning about the accelerator and detectors at FermiLab will help me explain to students how particle physics experiments are completed and how the muon detector at my school is relevant to this work. Example: Top Quark mass. The activities provide a way to incorporate particle physics ideas and applications into the standard physics curriculum. I am the only physics teacher at my school. QuarkNet provides me an opportunity to collaborate with peers, discuss curriculum and pedagogy, and develop new materials for my classes. Building a learning community has been very beneficial to my teaching. QuarkNet has opened my eyes to seeing how advanced physics concepts can be discussed in a high school physics class.	I plan to teach a unit on particle physics using activities from the data portfolio and the cosmic ray detector in my classroom. Examples: Top quark mass, mean lifetime, shuffling the particle deck. Having the opportunity to meet with other physics teachers and discuss content and pedagogy is extremely useful, especially for those that are the only physics teacher at our school.	I teach particle physics and astrophysics/cosmology in my Physics course. I will use many of the activities we worked on this week including from the Data Portfolio and new activities developed at JHU. Examples: Top Quark Mass, Hidden Neutrino, Particle Transformations. Collaborating with fellow physics teachers always brings out new ideas for activities or lessons to use in the classroom.	I teach a unit on quantum physics including particle physics. This includes the standard model and activities from the data activities portfolio. Examples: Top quark mass, Hidden Neutrino, Quark workbench. Hearing from Physics researchers about their current work and recent advances in physics provides excellent discussion topics for the classroom.	Top quark mass, Rolling with Rutherford, Histograms These activities allow students to explore particle physics concepts using physics they are learning in introductory courses.	DAP activities used when teaching E&M and modern physics units. Examples: Round the bend, Rutherford, Mass of Top Quark, Dice decay. It is good that the activities can be adapted to the school level and level of student knowledge.

Table (con't.)

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Johns Hopkins University	2019	2020	2021	2022	2023	2024
	Data camp and the masterclasses. Both have provided me with experiences and knowledge that I can bring back to the classroom and use with my students. I have not had the opportunity to really share with other teachers and, unfortunately, in today's test happy society, it is difficult to fit these topics into class and to convince others to fit them into class. In terms of building a local/regional learning community, I feel like that when we are together at a QuarkNet event/program that is true, but as soon as it is over, everyone sticks to their own little world and the community does not interact or collaborate. I had ask at a QuarkNet event once if there is some Facebook group or e-mail chain or even What's App/text messaging chain, so teachers could continue to talk to each other, share links/resources, and ask questions, and not only was I told no, but I was told that people generally don't want that and that people get too busy during the school year to do that. I disagree with that statement as I belong to several physics/STEM Facebook groups that work as great online communities.		I plan on using the spectral analysis activities we were working on this past week into my ninth-grade physics course. Examples: Mass of the pennies; What Heisenberg knew; CMS masterclass.	When teaching forces, I have a unit on the fundamental forces of nature where I present and the students explore the standard model and the reason why we have Fermilab and the LHC. The first lab is based on the Millikan experiment using histograms and searching for patterns. I tend to design my own activities, so I do not necessarily use the activities listed in the Portfolio. QuarkNet always provides me with new and innovative ideas to take back to the classroom and motivate me to continue to grow as a teacher.	Millikan experiment developing histograms. The projects based leaning with an inquiry approach drives my classroom instruction.	Great resources. I always refer to my inquiry approach as "guided inquiry."
	Data camp and the summer workshop The I2U2 site examples, specifically modern physics puzzle. Good resources there (DAP).	1. Use of the materials in classroom is great: The subparticle puzzle to start modern physics 2. Masterclass involvement and implementation 3. Standard model discussions, etc. Examples: 1. Quark puzzle/map involving learning color charge, bosons, etc. 2. Penny/coin activity	I have used a significant number of resources involving the QuarkNet workbench, some investigations and more. Overall, my last 10+ years at QuarkNet have really increased my knowledge of certain areas. Exs: The quark workbench, masterclass, J psi (occasionally). I really didn't see the benefit at first time, but over time (10 years or so) the community and the reinforcement of ideas has definitely broadened my horizons.	I intend to use my QuarkNet experiences in my own modern physics unit with all physics classes as well as having my Science National Honor Society students to listen to some of the speakers who come to our high school. Examples: The Quark Puzzle, Z mass activities, missing momentum, etc.	Quark puzzle workbench and the mass of the top quark	Workbench. It (DAP) has some really good things for students and teachers. It has some really good things for students and teachers

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	2020	2021	2022	2024	2025
Johns Hopkins University	Indicated use of DAP activities but no examples provided.	We have discussed the standard model and uncertainty while describing atomic theory. Examples: Mass of Pennies, Dice, Histograms, and Probability and Signal and Noise.			
	I love the dice rolling activities. There is something for everyone. Every level of teaching and every type of teaching, you can find something. I plan to use all the lessons we looked at and the race discussions we talked about. Everything was extremely useful this year. I really enjoyed it. Examples: Dice rolling, Rutherford, Cosmic ray muons. Collaboration with other physics teachers is always invaluable to me. I always use the dice rolling as an intro to the course because it gives them an intro to data but also problem solving.	I use the data activities portfolio activities pretty often. I also use the coding activities. Examples: Histograms, coin toss, quark workbench.		I use a lot of the coding activities. (DAP) They can be adapted very easily for different levels.	I use the coding notebook throughout the year! Examples; Quark work bench, most is not all coding activities, rolling with Rutherford, dice
	Data Camp - Gave me the time to work as a student and a teacher - A vital component to implementation. Z Boson - It serves as a great conservation of momentum 2-D lab. I can also have students research particle physics before or after. The lessons have student and teacher documents, hands-on learning and many extensions. Great community builders --only Physics teacher at my school.		I have used coding activities: introduce experimental design, resistive forces, and worked with LHC data to show the conservation laws. Will attend WWDD with my classes and offer Masterclass to my students. I have muon detectors to extend students' access to particle physics. Examples: 1. Used my implementation plan for the "Mass of Z boson;" my work at data and coding camp to have students complete the activity in Google Colab. 2. I use "quark workbench" to introduce science practices or the E & M unit. I have changed the emphasis of my course to embrace authentic data and particle physics talks solely because of QuarkNet	The activities are accessible and novel work with HEP.	I have used the Quark Workbench when discussing charge, Mass of the Z Boson using a version from Coding camp I created to teacher conservation of momentum, and have developed a particle accelerator project to create a cyclotron using a Wimshurst machine based on the CERN ITW (2023). Plan to try the Rolling with Rutherford activity this year. Example: Mass of Z boson, Quark Work-bench, Rolling with Rutherford. This year developed an electrostatic polarity detector. This can lead to a conversation about particle detectors.

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Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
	2021	2022	2023	2025
Johns Hopkins University	I have used the top quark mass activity the most often, not only as an approachable way to teach detector physics but also as an example of 2D momentum conservation. I use the quark workbench fairly often with my AP class as an introduction to particle physics. You can integrate particle physics without having to add extra time or lessons to your curriculum, and particle physics is a very interesting context for learning physics. Through the connections I've made at the JHU center, I've had a half dozen different physicists visit my school to talk to students about their research; I've been hired as a teacher consultant for the CLASS telescope to develop educational resources; I have a network of colleagues and friends in my state; I've met various professors at JHU and other universities who specialize in NGSS and inquiry-based instruction; and (through Data Camp) I have a contact list of almost 200 teachers across the nation I can collaborate with and ask questions of. Need I go on?? QuarkNet is an unbelievable treasure and I hope that someday we can secure funding to bring it back to its former glory. With my new conceptual class, I plan to use the rolling with Rutherford activity to show the students how we develop a model for the atom. If I can get kids interested this year, I'd like to use several of the muon activities in there (except for signal and noise #1 because it's terrible, which I am allowed to say because I wrote parts of it and am not happy with it)	QuarkNet shows up pretty much anywhere you want to put it. The top quark activity is a nice fit for not only vectors but also conservation of energy and momentum. Muon detectors are a cool way to test a constant velocity model and get a very surprising value for its speed. The use of histograms can help a 9th grade biology or physical science class understand that pennies have discreet mass. Examples: Top Quark, Pennies, Rolling with Rutherford, Dice Histograms Signal and Noise (once I fix that awful one I wrote). We are all partly-finished sculptures. I hope that QuarkNet continues to shape me into what a good science teacher looks like. These answers would be different if I checked what I HOPE my students will be able to do. But realistically, I think that QuarkNet and I can help them become better scientists. I came to "Boot Camp" in 2007, and began teaching physics in 2006, so QuarkNet is more or less coincident with my becoming a physics teacher. Since then, QuarkNet has opened so many doors for me and my students that to describe it fully would be to write an autobiography of my career to date. As I type this, one of my former students is surviving brutally cold temperatures in Antarctica as one of only 3 dozen scientists spending the entire winter there.	Top quark - use it for 2D momentum conservation in AP physics; penny histogram - use it in intro biology courses for data representation; rolling with Rutherford - use it with low level physical science courses for atomic theory and also showed it to the chem teachers; quark workbench - use it sporadically as a low pressure introduction to the rules of the standard model,	--Top Quark activity: used with context after students learn the conservation laws; with no context during the vectors unit. --Used cosmic ray detector extensively in 2023-4 and some in 2024-5; hope to continue in 2025-6. Some students also working on developing a smaller model using a Raspberry Pi and CMOS camera. --We participate in the WWDD in the fall and Masterclass in the spring, nearly every year. --Use histogram stuff when teaching the freefall topic in kinematics. Two things students really struggle with are not having lab instructions and not knowing whether their experiment was "right." The first one is pretty intimidating for students, and I tend to throw them into the deep end pretty early, while also trying to provide support, advice, feedback, etc. It felt like a real win when two students who audibly (but politely) made it known they hated the "no procedure" lab style, they were still able to successfully perform it by the end. Examples: --Top Quark --R.w.R. --Histograms --Muon lifetime & speed data express --maybe some more; haven't looked at the new ones yet. QuarkNet remains one of the only valuable PD experiences I've ever had in my 22 years teaching. It is certainly the only one where I've wanted to go back after the first year. It has utterly transformed nearly everything I do in the classroom, especially the way I approach labs and data analysis. My students have gotten involved in some really cool research as a result, and I wish there was a way for me to measure / document their investment in a way that provided good metrics for our funders.

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 **Johns Hopkins University**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year
	2021	2024	2025
Johns Hopkins University	CERN. The interactions with scientists and other physics teachers interested in the subject is invaluable. I greatly value my summer experiences.		
	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year
	2022	2024	Year
	The Summer Workshops. My favorite is the Quark Workbench and Mass of Top Quark activities. Good library of accessible activities for high school physics with high engagement hooks. Every summer, the QuarkNet Summer Workshop is an excellent use of my summer time to become educated about topics in modern physics research and latest physics pedagogy. For my above-average students who show a little motivation & interest in physics in my class, QuarkNet has been great to boost their learning well beyond the normal high school curriculum. For the less-motivated or less adept students, QuarkNet has not contributed anything. The activities are usually far too difficult for them to comprehend.	Quark Workbench is a great inquiry activity for students to observe data, look for patterns, and then test their own models by looking for additional data. Rolling With Rutherford is great for having students understand how observations from particle colliders leads to understanding of the structure of matter. I recommended it to other physics teachers. Many of them have since incorporated Rolling With Rutherford as an annual classroom activity.	Rolling With Rutherford, Mass of the Top Quark, QuarkNet Workbench. The Data Portfolio activities are great. The QuarkNet website needs a better Forum or Message Board where teachers can post questions or comments and we can more easily have a robust discussion.

Table (con't.)
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Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year
	2023	2024	2025
Johns Hopkins University	The Neutrino Workshop was an amazing introduction to particle physics. I now have a baseline level of knowledge and know what I need to do further. As a first time particle physics teacher, I would love to have more pedagogy and curriculum scaffolding to help me have a framework to work within for my grade levels. I have not taught this topic yet which is why I am here! I feel so much more prepared and feel that there are a lot of resources. I am overwhelmed with how to successfully implement this BUT I feel very confident that I have met several professionals here that will help me if I reach out if needed. I really got a lot out of these short 3 days!		I plan on using the activities in the QuarkNet data activities profile. I also plan on using the Implementation Plans to get ideas from the experience of other teachers. Examples: Have used - Particle Deck Plan to use - Z Boson Mass, Histogram Activities. Really enjoy the guest speakers!
	Coding Camp. I'd like to be able to code my own things for class. Quark Workbench was a neat way to show students how to build an atom, Very useful for modeling physics concepts. QuarkNet is an excellent way for teachers to introduce particle physics to students. I like the opportunity to meet with other physics teachers from the area that I would not otherwise meet. QuarkNet has been a great way to improve my teaching in the classroom.		
	Data Camp - This has been the most helpful to me so far. It's also the only QuarkNet workshop I've done so far. I have not had a chance to do any activities yet since this is my first summer in QuarkNet. Many of the activities are easy ways to incorporate particle physics throughout the school year. This is my first year in QuarkNet so I have not yet implemented any activities into my teaching. I'm excited to do so this upcoming school year!		I use e-labs when teaching topics related to vectors, momentum, and energy. I use a cosmic ray detector to help teach about the standard model. Examples: Rolling with Rutherford. Mass of U.S. Pennies Quark workbench. Many students become motivated when learning about the exotic science topics that the QuarkNet activities discuss and explore.
	This is my first time at QuarkNet and have not had a chance to put this information into practice.	Introduce particle physics in the conservation of momentum unit using the collision of particles. Examples: Mass of Pennies, Mapping the Poles, Rolling with Rutherford.	

Table (con't.)

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Center	Program Year (Year of Full Survey)		
Johns Hopkins University	2025		
	Coding Camp 1 - it is the only one I have attended so far. Using Colab or Jupyter notebooks to help students visualize data they have collected to help them analyze it better. I have learned a lot of new information and had the opportunity to collaborate with different educators from across the country with various backgrounds. The new information and collaboration has helped shape some new ideas of how to implement coding, data science, and critical thinking skills into my curriculum	.	

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As self-reported by one teacher: "one of my former students is surviving brutally cold temperatures in Antarctica as one of only 3 dozen scientists spending the entire winter there." (2022)