
Center-Level Portfolio: Virtual Center

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 **Virtual Center**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
Virtual Center	2019	2020	2021	2022	2023	2024
	No preference; all valuable. (Add) world wide learning community.	Modify "sequim science.com	When discussing "the world" with students, friends and family (retired).			
	No response.		I have incorporated a variety of activities when teaching conservation laws. Examples: StepUp, Rolling for Rutherford, Particle Cards. QuarkNet Rocks!	I will use many of the activities from the data portfolio as after school projects. Some of which will be used through while teaching conservation and quantum mechanics. Examples: Neutrino masterclass, Z mass, the case of the hidden neutrino. They are fantastic to use to make direct connections to contemporary physics.		I will bring students to Masterclass, have them participate in W2D2, and complete some of the data portfolio activities. In addition they will continue to use the CRMD. Examples: Missing Neutrino Z-Mass Rolling for Rutherford. It's an outstanding vehicle. 2025: I use many materials from the data portfolio to supplement the teaching of conservation laws, quantum mechanics, special relativity and other topics. I also have used my cosmic ray detector and have students participate in WWDD and Masterclass.
	I did masterclass with my students. They enjoyed doing research and meeting with other students on the internet. (Now retired.) Examples: Rolling with Rutherford. It gives better incite to the theories and problems the students encounter.					
	The structure of discovery and analysis of activities. Rolling for Rutherford is my favorite. Would recommend (DP) wealth of hands on Critical thinking that allows for group data plots.	Rolling with Rutherford, and dice decay				

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	<p>CERN - as much for the collegial nature and sharing of ideas, methods, and course structure. Examples: Rolling with Rutherford and Quark Workbench have been used consistently in introducing statistics and the structure of matter. I have recommended these activities widely, as they can also be used in other ways, introducing conservation principles into a "regular" physics class, for example. I think the use of these materials in a somewhat structured manner is important in setting up whole courses, or parts thereof. And my students were highly engaged. I've been building a regional learning community, and QuarkNet has provided me with many resources to share in this endeavor. QuarkNet has enabled me to interact with other teachers in a larger community.</p>	<p>I've already incorporated the Cosmic Ray and e-lab activities as well as Master-classes, and will add in what I've learned and developed in the Data Camp. These included lessons on CERN, conservation. Examples: Shuffling the Particle Deck Rolling with Rutherford Quark Workbench. The activities have been used in many ways, and some, such as Shuffling the Particle Deck, have been highly successful in a remote (virtual) session.</p>	<p>I'll use particle collision materials for Conservation on Momentum and Energy. Examples: Shuffling the Particle Deck, STEPUP Lessons. These have been great activities to reinforce, introduce, and pique interest.</p>	<p>I use the Data Activities Portfolio regularly for areas such as histograms (Mass of Pennies) to Conservation Laws and vectors products (Calculate the Top Quark). I also provide a masterclass. Examples: Mass of Pennies, Calculate the Top Quark Mass, Shuffling the Particle Deck (and more).</p> <p>These activities offer experiences that are beyond most curricula while bolstering and enhancing knowledge that is required by the State or LEA.</p>	<p>I'll use data from the CRD in class for programming. I'll also look over and use the wave materials. Examples: Quark Workbench, Penny Mass, Dice Histogram, Signal and Noise, Shuffling the Particle Deck, Calculate the Z-Mass, Calculate the Mass of the Top Quark, Rolling with Rutherford, Angles and Dimuons, Making it 'Round the Bend. This experience enriches many parts of the curricula for the various classes I teach.</p>	

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	CMS Masterclass. Many of my students have completed it so it provides a common reference and vocabulary when discussing momenta, energy, relativity, and energy-mass conservation. I do not believe that I am familiar with the 'Data Activities Portfolio' so I am unable to answer this question with any certainty. I am not certain to what the 'Data Activities Portfolio' is referring. It is possible that I have used these, but was not familiar with the name.	I use the Heisenberg Uncertainly lab when I introduce graphing and the concept of uncertainty. I use both WWDD and the CMS Masterclass when discussing Energy and Momentum conservation and as an intro. Examples: What Heisenberg knew, Quark Workbench, Rolling with Rutherford. It provides authentic experiences in data analysis and exploration for my students.	I've used them for conservation of energy and momentum as well as special relativity. I just moved to a new school with a new curriculum, and I need to find places to use them this year. It is always a positive experience for the students who often recall their time doing the activities.	CMS e-Lab, Cosmic Ray e-Lab. Easy extension activities for motivated students	Conservation Laws (momentum and energy), Uncertainty. Examples: Quark Workbench, Dice Probability, Mass of the Z-Boson.	We use the "What did Heisenberg Know?" data activity as part of our data analysis and graphing unit. We use the WWDD and Masterclass to discuss the conservation of Energy and Momentum. I plan to use the Special Relativity materials in post-AP sessions this year. It is a great resource to locate cutting-edge science and research

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	<p>CERN summer program. Long program (3 weeks), in-depth, working with teachers from many countries. I used Rolling with Rutherford, Quark Workbench, and Calculate Mass of the Z when doing Masterclass for the past 8 years or so. All seemed to be helpful in teaching various aspects of physics. There are several activities that could be useful. A teacher can look through an activity and decide whether it fits what they are doing. The things I know about are useful and helpful. There are some that I have not been aware of. I'm not sure if that's my fault or if they haven't been communicated loudly enough to overcome background noise common to teachers. Most of QuarkNet's help has been towards me, and thus indirectly to my students. Without QuarkNet I would have known virtually nothing about particle physics. My students would not have participated in masterclass, visited Fermilab or participated in the Fermilab Open House. I would not have been in the CERN summer program. QuarkNet enriched my career as a teacher (and learner) and it enriched my students' learning probably more than they realized or appreciated when they were in the classroom. There are several activities that could be useful. A teacher can look through an activity and decide whether it fits what they are doing. The things I know about are useful and helpful. There are some that I have not been aware of. I'm not sure if that's my fault or if they haven't been communicated loudly enough to overcome background noise common to teachers. Local/regional community is difficult where I live. Many physics teachers have weak backgrounds and teach multiple subjects. (That included me.) I have presented QuarkNet info at a local workshop, teachers were interested, but they did not follow through. Physics in small towns/schools needs work. Most of QuarkNet's help has been towards me, and thus indirectly to my students. Without QuarkNet I would have known virtually nothing about particle physics. My students would not have participated in masterclass, visited Fermilab or participated in the Fermilab Open House. I would not have been in the CERN summer program. QuarkNet enriched my career as a teacher (and learner) and it enriched my students' learning probably more than they realized or appreciated when they were in the classroom.</p>	<p>I've used CRMD for learning, also for Science Fair and Illinois Junior Science and Humanities Symposium presentations, I have had students participate in International Physics Masterclass. Examples: Rolling with Rutherford; Quark workbench; Calculating the mass of the Z particle. I'm retired now. The first time I really missed being in the classroom was when Masterclass time rolled around. Then the corona virus hit, and I am glad I no longer have to be teaching in a classroom.</p>				

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Virtual Center	Data Camp has been amazing, I can't wait to share my experiences with my students and to incorporate a number of activities into several of my classes (I teach 7 different subjects). While I haven't used any yet, I love the activities like Workbench that make abstract concepts concrete and manipulative for the students, these really help deep understanding. Teachers never have enough time, and to have access to high quality, standard aligned activities like these is wonderful! This is one of the best PD activities I've attended, usually you're luck to have half a dozen take-aways, this provides an entire portfolio. I will incorporate so many things learned into my teaching. The staff has been terrific, so helpful and encouraging, even when they almost made my brain explode doing data analysis! :)	Being a part of Virtual QuarkNet has been one of the very best professional development opportunities I have experienced in my 10 years of teaching. The cohort is amazingly supportive and knowledgeable.	I will offer a Coding with Python enrichment for students, and I will mentor a STEM student's OSEF Science Fair Project using the Cosmic Ray Detector. Example: Cosmic Ray E-lab will be an introduction used in STEM class to build student knowledge and engagement to develop the science fair project; using all coding activities will be offering a coding workshop. QuarkNet has allowed me to build my Content and Pedagogical knowledge, I am so grateful for the ability to participate. QuarkNet has allowed me to grow professionally, and I have shared the resources with the other science teachers in my school. It's a fabulous program, thank you!		I have tried with Masterclass but my Physics classes tend to be very small, 3-5 students, which is why I want to offer one to our schools. The resources as amazing for small schools like where I teach, we have no budget for labs, so this provides us with the opportunity to explore data manipulation, plus the kids think it's really cool that they're using real data from CERN.	

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	CERN was fantastic as it helped me better make the connections between what I teach and current physics research. (DAP) Have not used yet. I want to try them myself.	After learning more about the Cosmic Ray detector and some ideas on how to use it, I want to incorporate data collection and data analysis in my computational physics course. This is a new course for me to teach so I have a lot of open opportunities and I want to try to incorporate a variety of QuarkNet activities. One of my colleagues in the group set a great goal that I want to copy. Having really only done level 0 and 1 activities in the past, my goal will be to add in at least level 2 activity into my course. Examples: What Heisenberg knew Step Up: Careers in physics Calculate the Z mass Muon mass - calculating the mass of the muon using LHC data. QuarkNet keeps me excited about physics which definitely translates to my students analyzing LHC data to explore 2D momentum and conservation of energy, momentum at relativistic speeds.			The virtual group did a workshop on relativity this year which was super helpful to me because I am teaching a new course on modern physics which will start will relativity. We did several data activities (how speedy are muons, mean lifetime with dice, mean lifetime of muons) that I will use in this new course. Mean lifetime part 1: dice mean lifetime part 2: cosmic muons how speedy are these muons? With each QuarkNet experience, I understand physics, and especially particle physics, a little bit better which gives me the confidence to answer more of the tough questions my students present to me.
	Program Year (Year of Full Survey)			Subsequent Year	Subsequent Year
	2020			2024	2025
	Masterclass showed my students that real science is not cookbook. Examples: Rolling with Rutherford. It gives chances to practice skills like graphing while learning other principles.				
cosmic ray advanced topics: using the detector. Rolling for Rutherford, quark workbench, both great for explaining basic particle physics and collecting data. Good activities, versatile. All are well tested and produce good results and discussions. Very worthwhile interactions with other teachers in the field. Collaborations are excellent. QuarkNet has been an invaluable addition to my teaching practices. The collaboration with other cutting edge teachers is very useful. That alone makes the whole system worthwhile. Students have really enjoyed doing the masterclasses in the past and have benefited from them. Looking forward to continued interaction with the Virtual QuarkNet program.			Uncertainty. I am teaching astronomy at the college level, so I don't have many opportunities to use most of the standard activities. My QuarkNet experience is always fabulous. I gain much insight into particle physics and get more comfortable with interactions with students. There are always applications to my work in astronomy.		

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	<p>All! My main goal currently is to incorporate modern physics into the general physics curriculum to increase student engagement and enjoyment of the subject. All is new to me and all is helpful. N/A (DAP): to be used this year! Even if all we do is use the data for graphing practice, it will expose students at some level to topics in modern physics. I just haven't been with QN long enough to implement any of the data-based activities.</p>			<p>Cosmic ray detector for discussions about signal and noise, general data issues, histograms lots of the data portfolio activities for histograms, probability, conservation laws, standard model. Examples: Rolling with Rutherford, dice histograms and probability, histograms the basics, QuarkNet change the culture, calculate the Z mass, cosmic ray e-Lab. The data portfolio activities, cosmic ray labs, and the idea for slipping the data portfolio activities in all through the year have really helped my teaching be more interesting and engaging.</p>	<p>Data portfolio activities, mostly focusing on graphing and interpreting histograms, e-Labs using CRMD, all applicable to variety of physics topics: experimental design and uncertainty, conservation laws, modern physics, etc. dice, histograms, and probability; histograms, the basics; introduction to coding using jupyter; Great resources, great workshops, I'm really glad to be part of the program.</p>
	<p>I think what I learned in DataCamp will be very helpful. Masterclasses and W2D2 have also been helpful. Although I haven't used them (at least I don't think I have). The QuarkNet materials I have used were good and I am sure these materials are also useful.</p>	<p>I incorporated neutrino activities in my Cosmology class, I used the top quark activity for conservation laws and an introduction to vector addition. I plan to get my cosmic ray detector working. Examples: mass of Z mass of top quark signal and noise rolling with Rutherford step up particle transformations MINERvA</p>	<p>Cosmic Ray Detectors are used for special projects, neutrino and CMS masterclass for conservation laws, uncertainty and intro to particle physics, colab notebooks for teaching a variety of topics. Z mass, cosmic ray e-lab, rolling with Rutherford, and more. QuarkNet provides students and teachers with unique opportunities and is an important part of a quality chemistry or physics program at all schools that have QuarkNet teachers.</p>		

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Virtual Center	2024	2025
	Only one (workshop) gathering, great resources.	General Examples in Physics. Not used yet. Other issues arose when I had hoped to try some. Hoping this year will be better. Still getting bearings with particle physics. Was able to share about potential student experiences that I learned about through connections made here.
	The (NM) trip has been one of the most beneficial programs I've been in for a long time to help fill in my lacking knowledge in particle physics. New to program. I think these activities are very good for actual physics teaching but don't have a lot of teachers locally that can handle the level of physics and math involved. I'm relatively new to QuarkNet so the degree and magnitude of what I've been able to implement into the class is low at this point.	
	Coding camp. It gave the basic programming knowledge necessary to aid students with their projects and apply those for a Fermilab Trac Internship. The quark workbench, a modified signal vs noise. I am a member of the virtual group, I would really like a local group to start in the Orlando area so there would be a regional community. I would recommend that someone find some time in my schedule so I can do more and make improvements.	
	Program Year (Year of Full Survey)	
	2025	
	So far, the normal Workshop has been the most helpful. But as I am finishing up Coding camp right now, I am very excited to use some of the things I've learned this week!	
Learning how to properly analyze data and organize data. Examples: Rolling for Rutherford, shuffling particle deck. I would recommend because they are easy to use or easily adaptable to what you do in the classroom.		

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.

In a supplemental document to this portfolio, implementation plans created by teachers participating in 2024 and 2025 summer workshops are presented.