
Center-Level Portfolio: Lawrence Berkeley National Laboratory

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: **Lawrence Berkeley National Laboratory**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program
Lawrence Berkeley National Laboratory	2019	2020	2021	2022	2023	2024
	<p>Physics in and Through Cosmology has been the most helpful since it allowed teachers (and students) to get practical experience with using various QuarkNet tools for Atlas, Minerva, and neutrino data analysis using Arachne and Hypatia. With the advent of Next-Generation Science Standards (NGSS), school curriculum is in flux--and topics of study have not yet been firmly established at this time. The data is genuine and can be used to demonstrate the real-world application of scientific data in solving real-world problems and the relevance of key ideas in Physics. QuarkNet teachers now need to educate administrators and bureaucrats in state educational offices of the value of the QuarkNet curriculum in helping accomplish the objectives articulated in NGSS. Thank you for providing this amazing opportunity to students and teachers! It's high time to send school administrators and bureaucrats from educational entities to QuarkNet workshops to help them "get a clue" about how QuarkNet can be used to effectively implement NGSS into secondary school science curriculum.</p>	<p>QuarkNet materials were implemented into my General Physics classes in two areas: 1) study of forces, and 2) applications of Conservation of Energy/Momentum. The LHC was the primary tool. My current school Physics program has a fairly set lab schedule which makes it challenging. Help students make connections between the sub-atomic and cosmological scales. I wish I had a bit more flexibility with alternatives to requisite curriculum for Physics at my school.</p>	<p>I integrate the fundamental force carriers/The Standard Model when we introduce the forces unit. E-labs will be integrated on a case-by-case basis depending on the topics. Internet connectivity at my school is unreliable--so any access to websites or the 'Cloud' is on a hit-or-miss basis--which limits access to portals like QuarkNet's DAP. As we transition back to the classroom after 15+ months of remote learning--curriculum choices need to be very slow and deliberate to help assure that students stay on board. I have some concerns.</p>	<p>I wish funding were available to send district personnel and school administrators to QuarkNet workshops so that they could experience first-hand the value of their inclusion into science curriculum.</p>	<p>Rolling with Rutherford. The activities support inquiry-learning of Physics through applications in particle physics</p>	<p>When we study forces, I always present to students the particle interactions that are believed to be responsible for the fundamental forces. Time-permitting this year, I may use LHC data to support Conservation of Momentum. I consistently use Modeling Instruction developed at ASU and Physics Tutorials developed at U of Washington.</p> <p>Time-permitting, I may use the Quark cards and Tool Bench activities to reinforce the nature of fundamental particles and taxonomy in Science.</p> <p>In general--students have been entering my class with fewer scientific skills since the C-19 pandemic--so I need to be realistic in my expectations of what students can demonstrate. I wish that the NGSS included more particle Physics so that teachers could have greater latitude to integrate particle physics into their instructional curriculum.</p>

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Lawrence Berkeley National Laboratory	2019	2021	2022	2025
	The Minerva measurement was really useful. The effect of minimizing noise by using multiple-datasets was super-evident and I will definitely use this in my class as an illustration of the desirability of larger sample sizes. I have not used these activities yet (this workshop was my first introduction to them) but I will do so! They help students to understand how science is performed on large, modern instruments that are impractical for classroom use (since it is difficult to imagine getting a particle collider in my classroom!) This was the most amazing professional development workshop I have ever done (and I do not say that lightly--I have done some really great professional development workshops). Thank you so much for organizing!!			I incorporated several of the Dark Matter materials directly into my instruction. The students were very excited to have access to cutting edge content from current researchers in the field. I have used highly adapted versions. Rather than using an entire out-of-the-box activity, I incorporate small pieces (sometimes just single questions) into my existing labs and problem sets. As a teacher, it is a huge benefit to hear about current research in particle physics and be able to access materials relevant to this. Thanks for the workshops!
	The presentations by noted scientists help me to translate their information into small bits that students can grasp			
	I have appreciated the speakers sharing their stories about their journey into Science and the work that they do which really demonstrates the work of scientists and the most current research. I would recommend them (DAP) for the purposes of growing in an understanding of Science, but I'm not sure how well they align with state standards.			
	I never did the Data Activities Portfolio			
	I would recommend teachers look at the activities. The Heisenberg one in particular I thought was helpful since I teach the basic idea of the topic but never before had a concrete example with data to share. I would tend not to use some of the lessons that are focused on data reduction. More lessons that have students generate data would be ideal.			
	I would recommend it (DAP) to a teacher who wanted to teach about particle accelerators in depth.			
	Taught me a lot of things I didn't know that I hope to bring into my teaching this year. I'm not actually sure what this is (DAP).			
	While it might be hard to get some of the concepts into a traditional physics class, students these days have questions about current physics, and subatomic particles in particular. They might like a deep dive into how we know some of this stuff. I haven't used QuarkNet yet, so these answers are predictions rather than actual use. I really enjoyed the program and hope to use more particle physics in my classroom.			

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Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year
Lawrence Berkeley National Laboratory	2020	2021	2022
	This is my first BAMA workshop and I'm planning on using what I'm learning here in my teachings of chemistry. This workshop consists of a series of talks given by scientists in the field who are currently doing cutting-edge research in particle physics. You get to learn about their experiments and data analysis methods		
	<p>The 2002 teacher workshop at Fermilab is where I was first introduced to the idea of doing muon lifetime measurements with a cosmic ray detector. For several years, I would encourage a handful of interested students to measure muon rest-lives and also estimate the lifetime of moving muons (using flux measurements at different altitudes) to demonstrate relativistic time dilation. Later, these became a week-long lab that all of our honors physics students would do. In recent years, we have continued to use the detector to demonstrate muons, and to show anti-matter and the momentum of light using a radioactive SN-22 source. So the 2002 workshop had a very specific effect on my teaching. But really, the opportunity to work with and befriend physicists at LBNL over many years has had the more profound impact on my teaching. Through that, I felt I had really become a part of the broader physics community and began considering myself a physicist, and not merely a physics teacher.</p> <p>Mean Lifetime, Part 1: I actually developed a lab that was similar to this and used it for several years in conjunction with our Muon Rest Life Experiment. So I can't comment on the specifics of the version in the Data Portfolio, but the idea of rolling dice to build a histogram of particle lifetimes, and then using this to study mean-life and half-life, and to build conceptual understanding of how distributions of particle lifetimes are very different from lifetimes of people or pets, for example... that's a really valuable exercise for students. Rolling with Rutherford is another good one. Again, I didn't use this exact version, but something similar from an old edition of the Conceptual Physics lab book. Students were guided to develop their own formula to calculate the size of objects they couldn't see using only the statistics from collisions with marbles. Another powerful scientific exercise with direct application to particle physics.</p> <p>I'm also eager to share effective teaching strategies with peers and colleagues. Building a physics learning community with students, teachers and researchers has been the most valuable part of my involvement in QuarkNet.</p>		
	The topics in this workshop are beyond the NGSS and AP curriculum that I teach, and are more for enrichment. I have not been introduced to the Data Activities Portfolio.		
	I've only done one, it has been very helpful. Have not had a chance yet. I am looking forward to trying it (DAP) out this year.		

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Lawrence Berkeley National Laboratory	2021	2022	2023
	<p>Understanding more completely how particle detectors work, what they're looking at, and how particles interact and change in such short times and how that tells us about those particles as well as the particles from which they result. N/A so far. Maybe in the future as I'm able to explore the activities more. There seem to be a lot of types of activities that touch on a wide range of subjects. I'm really into using actual data rather than convenient hypothetical data. I like the progression for different levels of understanding. I didn't really get anything about pedagogy directly. I've learned a lot about content, and a lot of that content was delivered to me via good pedagogy, so I've learned by example, but there was no discussion of pedagogy directly. I don't really feel much more connected to these other teachers. I don't, for example, have anyone's email address except for Laurie and Ken. I don't foresee any furtherance of the relationship beyond or outside of other workshops.</p>	<p>I'm building a Cloud Chamber for my Astro students to observe subatomic particles. I'm using that to talk cosmic rays and aurorae. I'm using histograms to collate data on labs. I'm hoping to use some of the e-labs but I haven't had a chance to decide on which/how yet. My Astro class is a survey class so I don't get a lot of chances to dive deeply as many of the QuarkNet resources.</p>	
	<p>Original materials were too difficult to integrate. I haven't had the opportunity to delve into materials recently to see if something new might be helpful. It seems like quite a few of these answers are due to influences beyond QuarkNet, such as the amount of inquiry-based lessons already in my curriculum, and the fact that our district has eliminated honors physics (which gave more latitude, in terms of curriculum) and started AP Physics 1 and 2.</p>		
	<p>By far this summer Data camp because it gave me time to work on ACTUAL teacher plans. I have used the mass of a penny histogram activity. Until this workshop I really didn't know about all of the activities and I am excited to use them will ALL of my students next year. Many teachers are shy to give activities that they don't directly assess or for which their entire PLC does not want to implement. By providing a broad framework you make the skills accessible. The ratings reflect my desire to delve into more of the activities in a structured environment like this workshop. Sometimes I'm not brave enough to ask the question but I am always grateful that others do and I listen intently to their thought processes and the answers. I'd love to do more in my local area too but the opportunities are more for the students than the teachers. Both are important. The ratings on the influence are more a reflection of how many workshops I have gone to vs how much influence they have on my teaching practice. I plan on participating as often as I can and am accepted.</p>	<p>I plan on using the e-labs, Cosmic Ray detector and materials on QuarkNet to help with the standard model as well as conservation laws. In the past I have only done level 0 QuarkNet activities and now I want to incorporate more level 1s. Examples: Penny Histogram, Histogram the basics. This week really gave me the confidence to take the next steps in expanding my discussion on particle physics. I would like to now really learn how to use the muon detectors because I can see a clear path on how to integrate this into my curriculum meaningfully.</p>	

Table (con't.)

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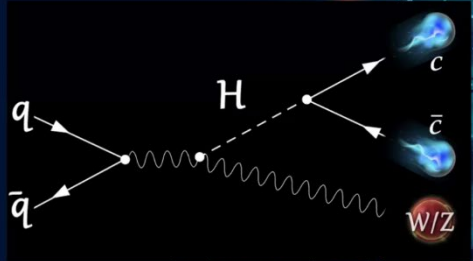
Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year
Lawrence Berkeley National Laboratory	2022	2023	2024
	Rutherford, Mass of the Higgs. If there is time to cover that topic they are fascinating.		
	The summer coding camp because I created something to use next year. More resources are always better. These workshops are of the highest quality. This workshop gave me insight on how to combine my programming skills with my physics teaching strategies. By learning new physics content, my interest in the subject stays high which allows me to keep my presentation of the content more engaging. By gaining new strategies to teach physics content, my students are gaining access to the use of tools that are relevant to success in contemporary society.		
	Program Year (Year of Full Survey)	Subsequent Program Year	
	2023	2024	
	I found a tremendous benefit to the Berkeley workshop this summer. I learned a lot and discovered multiple activities I will use with my students. This was not the case when I did the University of Cincinnati in person workshop around 2012. The person there was very disorganized, but they are no longer running it. I learned a lot and discovered multiple activities I will use with my students.		
	Program Year (Year of Full Survey)		
	2024		
	as part of the workshop, we have analyzed CMS or ATLAS data (depending on year). It is helpful to have updated knowledge of current research. This allows teachers to have more context for our lessons, make more informed decisions about what topics to emphasize, and better respond to student questions. 1. In our regular college prep classes, the current range of student abilities would make much of this material too many layers beyond what some can follow. 2. The expectation that teachers of the same course "collaborate" means that individual teachers are discouraged from introducing material that other teachers are unwilling or unable to introduce. 3. In the AP courses, we simply don't have time for the activities. I have been teaching for decades, and it would be easy to get stale and monotone in my teaching. QuarkNet workshops refresh my interest in physics, and make me a more knowledgeable and confident teacher. I am able to exchange ideas with other physics teachers with similar interests, even if those ideas aren't the planned lessons provided by the workshop itself. Away from a research center, it would be difficult to keep current on new discoveries in physics. Even if I was aware of a breakthrough, articles are often too simple (for people with little science background) or too complex (for scientists who understand topics many levels above me). These workshops provide a perfect bridge. The speakers consider this audience and tailor their presentations for the new and budding scientists. The speakers are often engaging and enthusiastic to answer questions, adapting their explanations to our questions.		
	While I have not used the exact activities in this portfolio, we do make our own muon lifetime measurements and analysis every year and we use dice to model the lifetime of a muon, similar to activities shown here. Interacting with other scientists and building a local learning community were two of the best outcomes of participating in QuarkNet for the first several years that I did so. In more recent years, we have just had one or two local meetings per year and no central science project that we were working on, so it's been a little less impactful.		

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. (Out of a total of 21 teachers.)

Below is an example of an excerpt from a student presentation given during a two-week virtual workshop at the Lawrence Berkeley National Laboratory Center from June 20-30, 2023. As reported in this center's Annual Report (July 20, 2023), a total of six physics teachers and 49 students participated via Zoom. As noted, most participating teachers and students came from public and private high school in the greater San Francisco Bay Area. As reported, "We have been making an effort to include underrepresented students in STEM (which include: African Americans, American Indians/Alaska Natives, Latinos, LGBTQ+, students from low income households, and first-generation college attendees) by outreaching to schools in lower income & underrepresented areas."

Does the Higgs Boson Decay into Charm Quarks Remain Consistent with Current Theories?

- The Higgs was purely theoretical for a long time and has many properties that we don't know about yet.
- It is commonly accepted that the Higgs decays into charm quarks.
- So far, research seems to match this prediction.
- If we find something that does not match the current theory, that shows flaws and could possibly disprove the current theory. This opens up the opportunity for further research.



The diagram illustrates the decay of a Higgs boson (H) into a charm quark (c) and an anti-charm quark (c-bar). On the left, a quark (q) and an anti-quark (q-bar) meet at a vertex, producing a Higgs boson (H) and a gluon (represented by a wavy line). The Higgs boson then decays into a charm quark (c) and an anti-charm quark (c-bar). A WIZ logo is visible in the bottom right corner of the diagram.

Source: Excerpt from Lawrence Berkeley National Laboratory Annual Report July 20, 2023
Screen shot from a student presentation. (Slightly modified to protect identify of student.)

Next is an example of students working on a cosmic ray detector during the LBNL workshop held June 16 to 20, 2025



Students working on Cosmic Ray Detectors

Source: Excerpt from Lawrence Berkeley National Laboratory Annual Report 2025
Screen shot. One student's face is redacted to protect his/her identity. Apologies no disrespect intended.