Center-Level Portfolio: University of New Mexico 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 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 **University of New Mexico Center**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
University of New Mexico	2019	2020	2021	2022
	WILL USE, since this is my first experience with them... Penny Histogram, Spectroscopy (which I have used for years but emphasized identifying chemicals, not particle differences). Definitely I plan to share the Portfolio. My school had only one teacher teaching AP Physics (bilingual) last year. She had only taught physics 2-3 years prior. I may be joining her in coming years w AP. We need and welcome challenging/relavant instructional materials on so many different content areas! We have also had a number of less than enthusiastic teachers assigned basic physics who may hopefully be inspired by this material. The Portfolio is especially welcome since it has the teacher instructions! I came with a great deal of trepidation since I am not currently teaching a "physics" class, and have not taken my multiple years of physics classes for decades. However, I have discovered that I am leaving with classroom materials which I plan to share with colleagues and apply some to my current content as well.			
	N/A - just learned about them this summer. I would recommend these because of their unique content and variety. I like that they are leveled and that you can filter them. While I have not explored many of them, I would note that some of them do not have enough detailed teacher guidance so that a novice teacher could pick them out and immediately start working with them. Some of them would need a good bit of teacher PD for effective use/understanding.	In my middle school "Super Science" elective class, I did use several of the introductory particle physics lessons from summer 2019. Mostly introduction to the standard model. Examples: QuarkNet Workbench, Shuffling the Particle Deck, Rolling with Rutherford.		

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 **University of New Mexico Center**

Center	Program Year (Year of Full Survey)	Program Year	Program Year	Program Year
University of New Mexico	2021	2022	2023	2024
	I always enjoy seeing how people teach, what they prepare in advance, what questions they ask! I will use the method of collecting data and making a table with post its--I'm sure it will come up, i like how intuitive it is and visual too.	Use of more/real data in the lessons (including histograms and analysis), some of the activities with students, stay in contact with other science teachers to share ideas/experiments arrange a presentation with real scientists or a virtual lab tour. Examples: Dice, Histograms, and Probability Histograms: Uncertainty, STEP-UP Careers in Physics.		
	(First year) I do not know what the Data Activities Portfolio is, but I would be interested in finding out. At the professional development that I attended I gained great ideas for teaching physics content in the classroom and increased my own particle physics pedagogy. All of the materials provided were high quality and useful.	Use of more/real data in the lessons (including histograms and analysis), some of the data activities with students, stay in contact with other science teachers to share ideas/experiments, arrange a presentation with real scientists or a virtual lab tour. Examples: Dice, Histograms, and Probability Histograms the basics Histograms: Uncertainty Step-Up Careers in Physics		Examples: Mass of a penny, histogram basics, dice histogram probability. Each activity has all the information that you need, including teaching information, student information, and materials. Each activity takes a different aspect of particle physics and breaks it down for the students.
	(First workshop) The marble/Probability activity. I would need more time to consider ways to make the workshop material applicable to classroom teaching.			
	With particle physics, I was able to apply the cloud chambers to atmospheric CCN for younger students.	I teach 6th graders, so cognitively, these topics are difficult to work with for this level of student. However, I will use the "rolling with Rutherford" and card sorting activity as inquiry activities. Examples: Mass of US pennies, Shuffling the Particle Deck, Histograms, Making Tracks, Rolling with Rutherford, Mean Life Decay: pt 1. I hope to include the changing model as an illustration/example	I do not teach physics or upper level chemistry. It is difficult to engage in the higher level of physics when one does not really understand the data analysis or is unable to apply information into classroom.	

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 **University of New Mexico Center**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year
University of New Mexico	2022	2023	2024
	Rolling with Rutherford Has some good statistical practice activities. Since I just got involved with QuarkNet, it hasn't yet impacted my teaching or student knowledge.		
	I have used the Rolling with Rutherford activity in my chemistry class. It was a fun and insightful activity to do with my students and I can see doing it more. I would recommend all of the activities I have tried to physics teachers with a decent to strong understanding of particle physics. I personally felt uncomfortable with some of the activities before attending this data camp.		
	(First year) *Planned:* Histogram creation and bin sizing Use of spreadsheets for analyzing data sets. I will be recommending this to other teachers because it represents the SOTA of statistical analysis and data presentation. I am a retired nuclear engineer teaching physics now. Even with that background, I have learned so much new nuclear physics material and the status of present particle physics research. In addition, I have learned best practices on how to teach particle physics at high school level.	Will use the data plotting routines to demonstrate the influence of different physical and environmental parameters on muon detection.	I have the Cosmic Ray Detector in my classroom at La Cueva High School and use it when we discuss cosmic radiation originating the various sources in the distant universe. I will use this specific class to teach students on real data analysis using spreadsheets. I have already developed lessons using and programming a spreadsheet (google sheets). Google 'sheets' spreadsheet incorporating the data analysis functions built into the program. This is my third QuarkNet class and each class has a different topic emphasis which I have been able to implement in some manner into my physics lessons. In doing so, the students have got a realistic visualization of what particle (quantum) physics is all about.
	Particle shuffle, Rolling Rutherford, Step Up, and Z-boson activities. I already use a guide-inquiry science curriculum. What I learned in the workshop suggested additional activities that bring in Cosmic Ray and Atlas ideas.		
	I plan on using the penny mass activity and Rolling with Rutherford. I'll let you know in the future which one ends up being used more and how. It's helpful to have already curated activities especially for particle physics which is something that many teachers don't have much experience with it.	I was able to use the CRMD in my Exploring Physics elective and had a few students use the CRMD for their science fair projects.	
	Rolling with Rutherford for model design and experimental set up. The few activities I viewed included a statistical portion which adds to their instructive use.		Shuffling the particle deck
	I think I will use Mass of US Penny, Step-Up program, Rolling with Rutherford (first exposure to QuarkNet)	I plan on using the Half-Life dice game to learn about particle decay.	Here is the link to my implementation plan https://docs.google.com/presentation/d/1Ykk9lWROy-QVi2mMVPsXuwZKitnqcmClJaLDU5Kws5Q/edit?usp=sharing I have a CRMD that I will be using in the classroom this year and have used Shuffling the Deck 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 **University of New Mexico Center**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	
University of New Mexico	2023	2024	
	Dice activities, penny activities, Rutherford activity. Good learning activities for the students.		
	(First year) I have learned about a lot of these activities at this workshop this week and am planning to use several of them in my classroom this year.		
	The workshop I attended this week in particular has advanced my knowledge and experience with QuarkNet significantly. I feel much more confident incorporating these concepts and activities into my classroom.	I am currently planning to use activities on histograms, the z boson, and shuffling the particle deck (among others)	

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 following pages present an example of student work from a classroom visit by a QuarkNet staff teacher who engaged students in two QuarkNet DAP activities, *Shuffling the Particle Dec*k, and *Rolling with Rutherford*. This visit was at a public high school where the teacher is a participant in QuarkNet at the University of New Mexico Center. Each group example represents the work by a group of students. After the group completed their work, the whole class engaged in a "field trip" around the classroom to learn the justification for each group's work. (As per email from S. Wood December 15, 2023.)

After this, an implementation plan proposed for a participating teacher for the 2024-2025 school year is presented.

Particle Cards

Organize the cards on the next slide based on the properties printed on the front of each one. Resize the cards as necessary to see the information, and then arrange them in groups based on what makes sense to you.

Group 1: Quarks

TOP QUARK
DISCOVERED: 1995

MATTER PARTICLE

Mass:	$173 \cdot 10^3$ MeV/c^2
Electric Charge:	$+2/3$
Strong Charges:	blue, red, green
Weak Charge:	$+1/2$
Lifetime:	$6 \cdot 10^{-25}$ s

CHARM QUARK
DISCOVERED: 1974

MATTER PARTICLE

Mass:	1300 MeV/c^2
Electric Charge:	$+2/3$
Strong Charges:	blue, red, green
Weak Charge:	$+1/2$
Lifetime:	10^{-12} s

UP QUARK
DISCOVERED: 1969

MATTER PARTICLE

Mass:	2 MeV/c^2
Electric Charge:	$+2/3$
Strong Charges:	blue, red, green
Weak Charge:	$+1/2$
Lifetime:	unlimited

BOTTOM QUARK
DISCOVERED: 1977

MATTER PARTICLE

Mass:	4200 MeV/c^2
Electric Charge:	$-1/3$
Strong Charges:	blue, red, green
Weak Charge:	$-1/2$
Lifetime:	$2 \cdot 10^{-12}$ s

STRANGE QUARK
DISCOVERED: 1969

MATTER PARTICLE

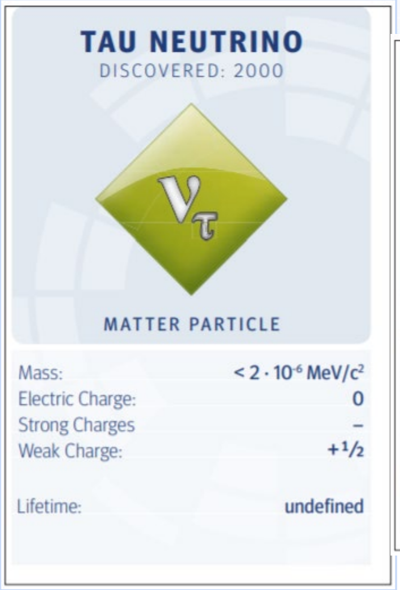
Mass:	100 MeV/c^2
Electric Charge:	$-1/3$
Strong Charges:	blue, red, green
Weak Charge:	$-1/2$
Lifetime:	$5 \cdot 10^{-8}$ s

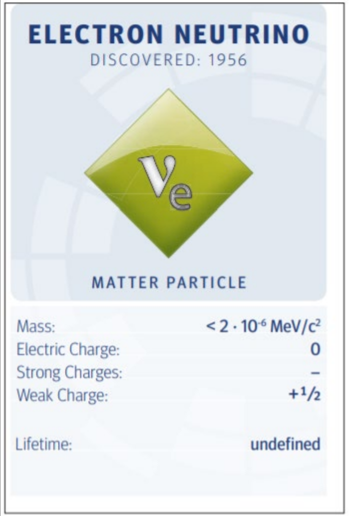
DOWN QUARK
DISCOVERED: 1969

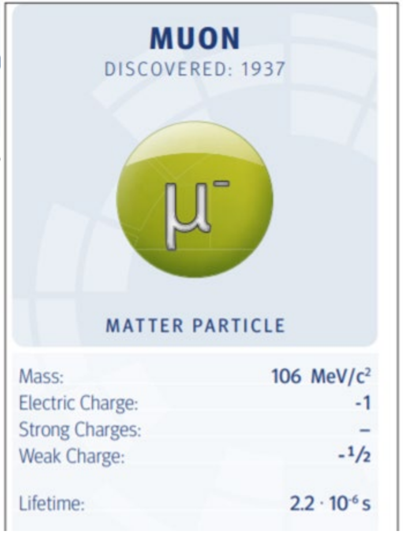
MATTER PARTICLE

Mass:	5 MeV/c^2
Electric Charge:	$-1/3$
Strong Charges:	blue, red, green
Weak Charge:	$-1/2$
Lifetime:	900 s

Group 2: Leptons

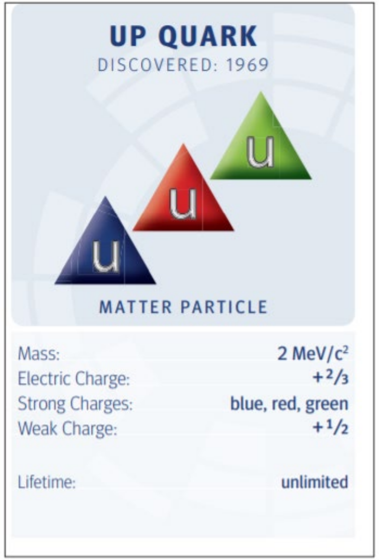


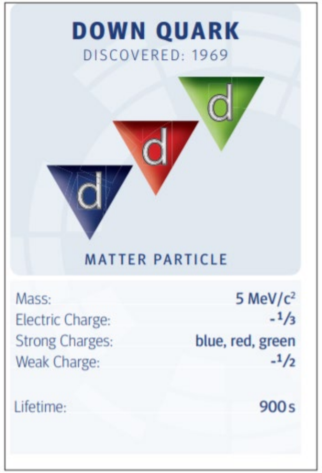


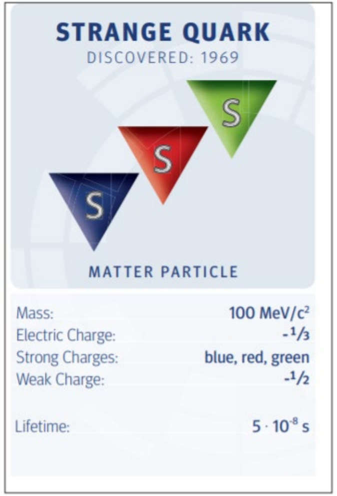


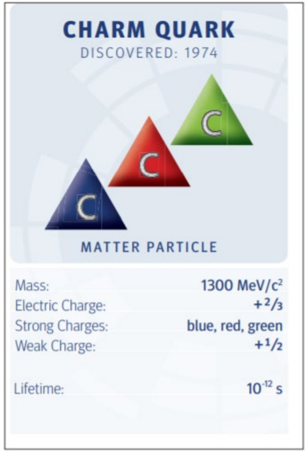
Group 3: Bosons

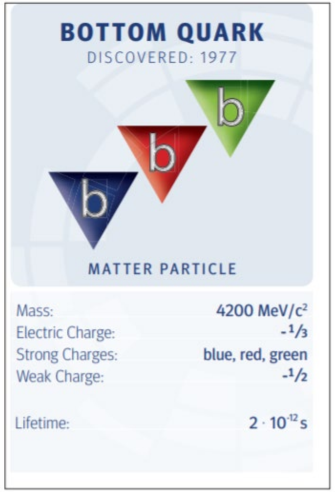
Group 4:
Quarks

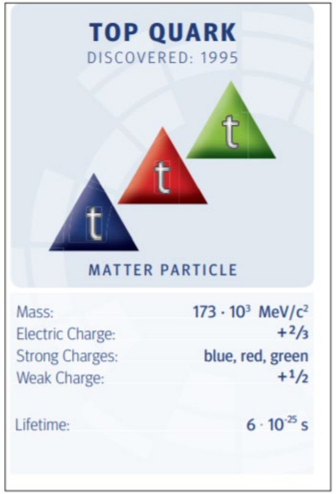




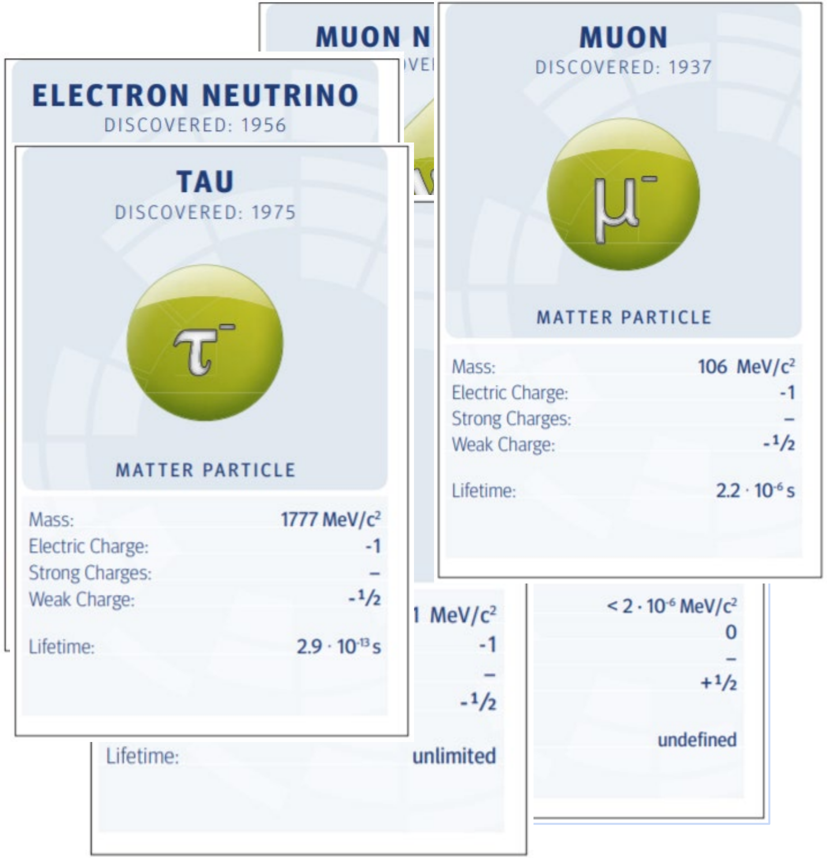




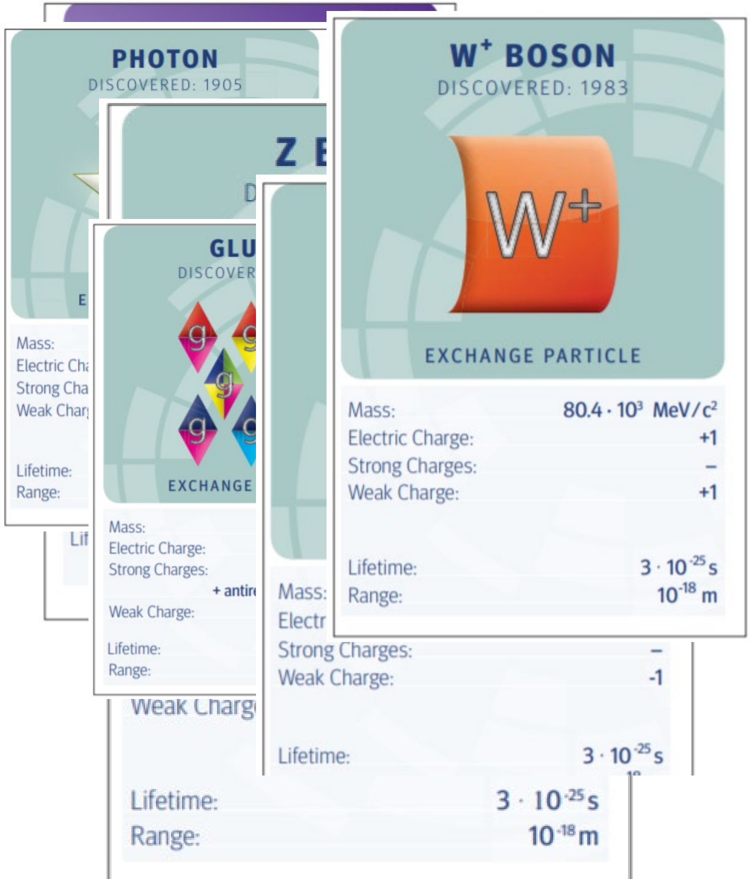




Group 5: Leptons



Group 6: Bosons



Implementation Ideas: 2024-2025 School Year

1. Chemistry -
    a. 3D printed quarks - Why are protons positive? How are protons and neutrons the same/different? (part of atomic structure topic)
        i. Quark Workbench 2D/3D | QuarkNet
    b. Elements Colab notebook/assignment
        i. Increasing familiarity with periodic table/periodic trends

2. Physics
    a. What happens when protons collide activity
        i. Energy - what is it? $E=mc^2$
        ii. Nicole's slide with fruit
    b. Motion graphing (position v time graphs)
    c. Velocity graphing
    d. Introductory graphing template notebook (Just an idea right now)

3. StepUP
    a. Careers with physics degrees