Center-Level Portfolio: University of Oklahoma/Oklahoma State

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 on their use of QuarkNet content and materials in their classrooms (and in-after class events). We see the value of these qualitative reviews as expanding on the instructional practices measured quantitatively via Teacher Survey responses. The table provides answers to select open-ended questions providing narrative examples of implemented or planned instructional practices by teachers in their classrooms and school environments. This evaluation approach is consistent with the use of *authentic assessment* as a means 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 skipped the question (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 **Oklahoma State University/University of Oklahoma Center**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
Oklahoma State University/ University of Oklahoma	2019	2020	2021	2022
	I have not used the Data Activities yet, but would like to learn more about how to integrate them into my classroom.			
				I will definitely bring students to the Masterclass. I like the Polar Bear activity and the Rolling with Rutherford activity.
	None	I use many QuarkNet activities already in my classroom. I will certainly use the Step Up activities this coming year. Examples: Card Game, Rolling with Rutherford, Calculating z particles		
	Dice, Histograms, and Probability Mass of US Pennies			
	I have taken students to a master class at Oklahoma state university	I plan on using Step Up plans as a new item to work with as we move forward. I have used other lessons for years from the QuarkNet program.		
	Quark workbench, Rolling with Rutherford, Isotopes of Pentium, various games with dice	Use cosmic ray detector as example of real time data gathering and large data sets. Used top quark mass to introduce particle accelerator and reinforce vectors as an analysis tool. Use quark work. Examples: Quark workbench Penny mass Top Quark mass		
	Quark workbench, particle deck, calculating top quark mass, particle adventure website, z-path, phyching out the system			
	I have used these for chemistry not physics class. I think that QuarkNet needs to expand their thinking about just wanting physics teachers. It has helped me go deeper into my lessons with chemistry students when talking about the atom. Before, it was so superficial. I have a better understanding and therefore I think my kids will too. This can be the first step toward a better physics class that students take the following year. I have used the marbles and dice, mass of pennies, and particle deck.			

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Oklahoma State University/ University of Oklahoma	2019	2020	2021	2022	2023
	I have really only pulled information to help/work with individual students.				Mass of pennies, histograms, uncertainty, roll with it. Good way to introduce how "real" science works from experiment design to data collection to what you expected vs. what you got. Some of the material is too in depth for some levels for the students (i.e.. Physical Science students not quite ready for some of the material). This is a wonderful opportunity for resources for me and resources to pass along to my students.

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Oklahoma State University/ University of Oklahoma	2019	2020/2021	2022	2023	2024
	Quark Workbench Determining the mass of the top quark Determining the mass of the Z boson Deck of Particle Cards Rolling with Rutherford. The activities actively engage the students, and they are related to real science. For example, I like using the quark workbench because it does a great job of having students recognize trends, make hypotheses, and test their hypotheses. In addition, it teaches them real science content. The same activity could have been done with naming the quarks anything and the students still could have found the patterns. However, the activity lets them ignore the names to focus on the patterns, but they are still getting used to seeing all of the names, colors, and fraction of charges. This makes it easier to talk about the zoo of particles later without them getting initially confused by all of the different names.		I use the quark workbench, particle physics deck, Rolling with Rutherford experiment, particle adventure website, and determining the mass of the Z boson, and top quark activities. I have gone to Masterclasses in the spring and I plan to go again. I also have done World Wide Data Day with students in the fall, and I was able to go to Fermilab for Data Camp. From this year I would like to begin introducing some coding to my students, but as of now my district has refused to allow Google Colab to be used on the district computers. So, I need to iron out issues with the district before I know what I will be able to do in the future in the classroom. Examples: I use the quark workbench, particle physics deck, Rutherford experiment, particle adventure website, and determining the mass of the Z boson and top quark activities. I have gone to masterclasses in the spring, and I plan to go again. I also have done the day of data with students in the fall, and I was able to go to Fermilab for the data camp. From this year I would like to begin introducing some coding to my students, but as of now my district has refused to allow Google Colab to be used on the district computers. So, I need to iron out issues with the district before I know what I will be able to do in the future in the classroom.	Particle Deck Quark Puzzle Mass of Z Boson Mass of top quark Rutherford Experiment Dice Rolling. Connecting science process and real data to concepts we are already covering in the classroom. I have shared the curriculum with multiple teachers. Coding: cannot use google. This year another teacher showed me replit so that I can use it to run the curriculum.	Finding mass of top quark and z boson, quark puzzle, and particle deck are the ones that I use every year. (Students are) able to collect data themselves, or good data provided to make concepts more accessible.

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Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
University of Oklahoma/ Oklahoma State	2020	2021	2022	2023
	Rolling with Rutherford			
	Rolling with Rutherford.			
	Data activities: Histograms, Quark WorkBench 2D/3D. Rolling with Rutherford.			
	I have used the Cosmic Ray activities in a school club setting			
	Program Year (Year of Full Survey)			
	2022			
	I plan to use the panda game and the Rutherford boards with my 5th grade science classes this year			
	Program Year (Year of Full Survey)			Subsequent Program Year
	2023			2024
	I also teach Astronomy so I plan on bringing more lessons and labs around neutrinos into both Gen Physics and Astronomy. Please ask me this next year! I'm sure I will be using several!			From last year we spend more time in-class discussing neutrinos as they relate to nuclear Fusion within the heart of stars. Examples: Mean Lifetime-Dice Particle Deck Cosmic Ray eLab! The acquisition of Nuon detector for my students will open up opportunities for my students to collect and analyze real time data that THEY will collect. I will be sharing the detector with another physics teacher within our district at another high school!
	Shuffling particle deck will be excellent to introduce standard model. New to program, will be able to assess better after implementing this year			Rolling with Rutherford, Histogram, quark workbench. Comprehensive, easy to use activities. Science must be hands on!
	In the past we have done the cosmic ray detectors and looked at data sets. The interactions between teachers are vitally important for building education networks.			Cosmic Ray Detectors. Good way to interest them (students) into particle physics.
	Haven't had an opportunity to use any yet (new to program).			Conservation laws and linearization. Mass of Z boson
	The "Dice, Histograms, and Probability" activity supports student data collection, graphing, and analysis skills in Chemistry. This can also be applied for radioactive decay. After introducing subatomic particles and quarks, the "Shuffling the Particle Deck" data activity is a great way to introduce the standard model. Other activities I'm interested in are "Rolling with Rutherford" and "Quark Workbench."			
	The 'Shuffling the Particle Deck' and the 'Mean Lifetime' activities. … the Portfolio has a wide range of activities that a variety of teachers can use to teach their students. I like the differentiation of materials available so that classes of various levels (like on-level students, below-level, or even up to AP level) have options in terms of how difficult the activities are for them.			

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Center	Program Year (Year of Full Survey)	Subsequent Program Year
	2023	2024
University of Oklahoma/ Oklahoma State	I do plan on utilizing the missing neutrino exercise to illustrate how the laws of conservation of mass/momentum/energy and vector diagrams used to detect the "missing" neutrino.	
	Like to have more hands-on activities	
	I love that these activities give students access to real experimental data. The size of the data pools makes these activities stand out vs other data pools which are usually given to students.	
	Dice Probability. It helps us to use real data and labs that are being used in real life to explain science concepts and how science learning progresses. I plan on using Quarknet materials in my classroom this year. This is my first exposure to particle physics.	
	I plan to definitely incorporate some of those activities within my class. For example: The Mass of U.S. Pennies and the Dice, Histograms, and Probability activities.	
	Not yet (new). The activities that use actual data from experiments is a great way to expose students to actual physics research.	
	I enjoyed the Fermilab Case of the Missing Neutrino and the dice roller and Shuffle the Particle Deck Yes, it's a great way to intro students to Particle Physics	
	The Muon Has Its Moment and The Case of the Missing Neutrino helped my understand the *whys* of the first day. These inspired some constructivist lesson/sequencing ideas.	
	Dice, Histograms, & Probability; Shuffling the Particle Deck; Calculating the Z Mass	
	I haven't used this yet, but I think I will use the hidden neutrino activity and data. I think that students are much more interested in real-life data. I am very excited to utilize the new information that I have learned for my Physics classes next year.	

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.

OU Implementation 2023

Please enter the implementation plans for your group to the appropriate slide. If you need more space, add a slide!

Group 1

For Biology and ACT using histograms to graph and synthesize data.

AP Physics - use the Case of the Missing Neutrino event data as an addendum to a two-dimensional collisions lab.

AP Research - utilizing the History of Science Collection at OU to investigate the history of research in science.

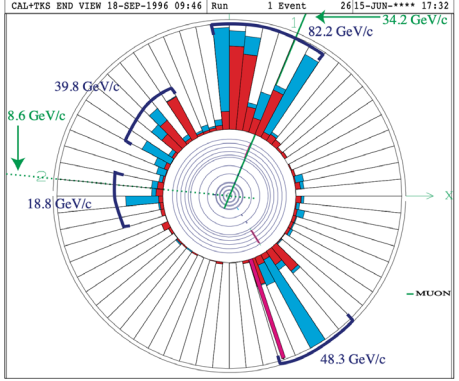
Science club - utilization of masterclass

Physical Science-exposure to scientific thinking and graphing, Dice, histograms

Group 2

- Physics
  - Muon Particle Detector will come back into use.
  - Probability of radioactivity decay.
- Chemistry
  - Examination of the Standard Model looking at the exotic particles.
  - Modeling quantum numbers
- All labs
  - Include error on predictions and measurements using bar graphs and bell curves
  - Virtual labs: Cosmic Ray Studies, Phydemo, Falstad, PhET
  - Use eV/c^2 as a dimensional analysis exercise

Group 3



<u>What are you looking to do?</u>

Data collection and analysis through Histograms (FWHM for uncertainty)

Dice Probability tied into Coin Probability. Exploring misconceptions of Probability between single and compound events

Using Fermilab data to measure momenta via vector addition in 2D to discover evidence of particles(momentum)

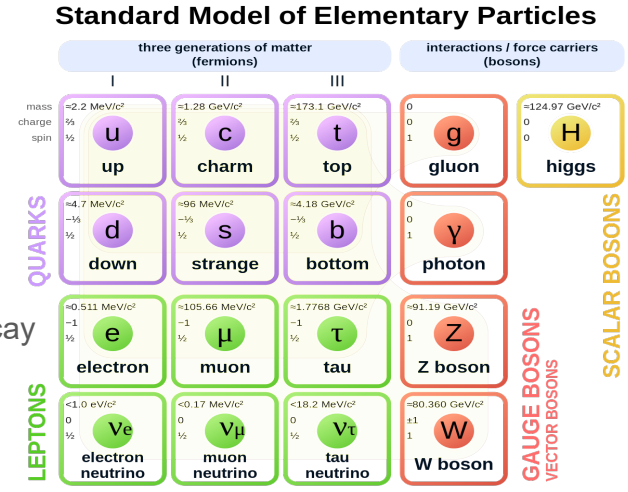
Introduction to Standard Model/Particle Physics (Shuffle the Deck Activity)

<u>What class?</u>

Physical Science, Chemistry, Physics

<u>What unit?</u>

Lab/Data Skills, Conservation of Momentum/Energy Units, Waves and Radioactive Decay



Group 4

Physics/ Chemistry/ Physical Science

- The “Dice, Histograms, and Probability” activity supports student data collection, graphing, and analysis skills. This can also be applied for radioactive decay.
- After introducing subatomic particles and quarks, the “Shuffling the Particle Deck” data activity is a great way to introduce the standard model.
- As a possible extension activity, students could be placed into groups and have them research different neutrino experiments such as ATLAS, NOvA, DUNE, MINERva, LHC, etc. being conducted around the world.
- For high school physics students, the “Case of the Missing Neutrino” activity is a great application of conservation laws to a more interesting situation than two carts on a track.

Group 5

Teacher #1 - I plan on using the muon detector to collect data and show to my astronomy students. For my Physical Science students, I will use the data collected from the detector for basic graphing of information. It was also very helpful to get the latest information on Neutrino experiments as well as updates on Dark Matter research. I learned a lot about Dark Photons this meeting.

Teacher #2 - I am going to start making use of the stuff in the quarknet data activities portfolio. The dice and histograms and probability activity will be really useful for helping physics students understand how averages work out over time.

Teacher #3 - The physics students will use a dice roller to show the distribution of data. I also liked the use Replit in place of some of the software that is available to me at my school. This was shown to me by Jessica.