Center-Level Portfolio: Rice University/University of Houston

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 **Rice University/University of Houston**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
Rice University/ University of Houston	2019	2020	2021	2022	2023	2024
	Mass of the US penny. I would recommend many of the activities to describe how particles work. These are helpful for beginning and experienced physics students because they are arranged at different topics and levels. I love how organized all of our activities are in the data portfolio with teacher and student resources and that I can pick the level and strand to use with my students. When planning my next year's physics class I will be able to use the portfolio to add several activities to my class QuarkNet has been very helpful in giving me resources and practice using those resources for particle physics concepts. I look forward to bringing things to upper level physics students that will make them interpret data and come up with conclusions that support it.		I plan on getting my cosmic ray detector working and try doing some e-labs and masterclass. Examples: Mass of Pennies Shuffling the particle deck Making tracks 1. I am really excited to use CMS data and the cosmic ray detectors.	This year I plan on incorporating histograms and coding into my classes. I plan on using simple coding with matching potion time graphs to have students graph motion. I will be also using the standard model and have a much better background for teaching it. Examples: I have used the shuffling the particle deck and Rolling with Rutherford. I plan on using mean lifetime part 2 this next year for a more original way of doing half life representation. I am excited to use more of what I have learned this year about particle physics. I will be much better prepared this year to teach that unit.		I have used the standard model cards, and half life of the dice, I will add on Energy, Mass and Momentum, particle transformations, Feynman diagrams, making it around the bend and the half life of a muon. QuarkNet has been the most important and helpful resource I have received when it comes to anything on standard model and particle physics. Without the info that I have gotten over the last couple years, I would not have been able to properly prepare my IB Physics students for their tests and all of the particle physics that is on it.
	So far, I have not had time to do a complete activity, but I have pulled out portions of LIGO e-Lab, Quark Workbench and CMS Data Express.	I teach the conservation laws as part of the required state curriculum. I give my students a Standard Model lecture during the 4th quarter each year and I have them explore the Particle Adventure online. Examples: I used Rolling for Rutherford when I taught Chemistry. I would like to use Mass of Top Quark.	I plan to use the Step Up Careers Activity and Masterclass prep: Standard Model, Conservation Laws, Mass of Z activity. I have also taught about Gravitational Waves. Examples: Mass of Pennies, Particle Cards, Mass of Z Calculation.	Have done Rolling with Rutherford, Masterclass and Standard Model presentation. Plan to do Shuffling the Particle Deck, and Coding Activities. Examples: Use Rolling with Rutherford already, Plan to use Shuffling the Particle Deck and more STEP UP activities like Careers in Physics.	Rolling with Rutherford really gives a good example of indirect measurement. The variety is nice, including the introduction to coding - a necessary skill for the future. I appreciate all of the ideas given to teach Inquiry based science. I also really like the Professional Development opportunities through QuarkNet	I intend to incorporate my "Standard Model" talk when I am reviewing the parts of an atom. I don't just stop at protons, neutrons and electrons - I include the quarks. I also plan on using a modified version of Rolling for Rutherford during our Atomic Theory unit. Students can see how "indirect measurement" works. Examples: Rolling for Rutherford, Particle Workbench (Particle Cards), Mean Lifetime (Rolling Dice) I get all sorts of questions about Dark Matter and other topics that pop up in popular culture. QuarkNet has given me the ability to answer some of those questions (not all! but some)..

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 **Rice University/University of Houston**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
Rice University/ University of Houston	2019	2020	2021	2022	2023	2024
	Mass of the Penny, Quark Workbench, Shuffling the Deck, Rolling with Rutherford, Mass of Top Quark	I intend to use coding in the jupyter notebooks for both my engineering classes as well as my physics classes as a way to deal with large data sets as well as some basic coding skills. Examples: Penny Mass, Quark Workbench, Dice Histograms		I will be using short coding activities throughout my courses. I use data activities as year starters (Shuffling the Particle Deck and Quark Workbench). I also use particle physics and momentum conservation. Examples: Shuffling the Particle Deck, Quark Workbench, Calculating the Z Mass.	Shuffling the Particle Deck is used as an intro to my AP Physics C courses to demonstrate where current physics is and the importance of learning the basics. My teaching continually moves to more inquiry based due to my experiences with QuarkNet and the students love and "hate" this. Love the hands on but sometimes "hate" making their brain work/hurt (though they always appreciate it later).	I have a collection of coding notebooks that are ready to be used in both my AP physics classes as well as my astronomy classes. I will use them to not only show students real life data usage but also incorporate some usage of python in analyzing data. Examples: Mass of the penny, quark workbench, shuffling the particle deck. I love how the material is prepared for multiple levels of student learners and methods of incorporating into multiple courses.
	Rolling With Rutherford Particle Adventure Mass of US Pennies Quark Workbench Dice Histogram Particle Deck Cosmic Ray E Lab		For beginning measurement and atomic theory, we are going to use Rolling with Rutherford and Massing Pennies. I love the idea of making a histogram of class data for the day and complete a post lab data analysis. Examples: Rolling with Rutherford Mass of Pennies Particle Cards	Describe the experimental design and conclusions used in the development of modern atomic theory, including Dalton's Postulates, Thomson's discovery of electron properties, Rutherford's nuclear atom, and Bohr's nuclear atom. Describe the characteristics of alpha, beta, and gamma radioactive decay processes in terms of balanced nuclear equations. 1. Probability with multi sided dice	Decay activity, Rolling with Rutherford, Histograms and Probability. The data portfolio is an awesome resource.	I plan to share my experience at my QN2024 workshop. Then, I will plan a QN2025 workshop around the experiments we toured such as DUNE(neutrinos) and LUX-ZEPLIN (Dark Matter). I appreciate the shared folder made available so I can prepare for my presentation. For my students, I can share my experience in my classroom and introduce some concepts into the Masterclass projects. Today I met a neutrino physicists from TAMU. Examples: Rolling with Rutherford, Energy, Momentum, Mass Particle Transformations Mass of Z How Speedy are these muons? I love QN, thank you for the opportunity to work with some many amazing people.

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 **Rice University/University of Houston**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
Rice University/ University of Houston	2019	2020	2021	2022
	I think engaging with the data would be the most helpful to students. They will learn to discover how to interpret data from different perspectives		I plan to use QuarkNet activities at the beginning of the year with careers in physics. I plan to use the particle cards to introduce modern physics to students. We can use the mass of z with the conservation unit. Examples: Mass of pennies, particle cards	
	Shuffling the Particle Deck - It is a GREAT introduction to the standard model for students who have never seen it or are just learning about it. It also allows them to use pattern recognition and critical thinking to help students gain better understanding. I do like and use several others for similar reasons. I also like the teacher notes and organization of the activities, it makes using them much easier.		District Workshops sharing information, Careers in Physics, Detector Studies, analyzing data, scientific method, Mass of Z, histograms, Current Events. Examples: Mass of Z Particle Cards W2D2	
	I used the data from CMS e-lab where my students do their own research and provide their outcome in form of research paper as a project.		I am going to create lesson plan where students learn about quark particles while they do research about various colliders while searching latest news. Examples: 1. Rolling with Ruth. 2. Mass of Z 3. Particle cards while printing sets for each group.	Data Activities, Content Knowledge using the Standard Model, STEP Up activities, Professional Development for Teachers. Examples: Plan to use: -Intro to coding - Energy, Momentum, and Mass -Step up - Changing the Culture.
	The activities give real world examples of advance physics concepts that can be used to teach physics fundamentals. CMS data can be used to teach conservation of energy, momentum as well as dimensional analysis application, concepts and even where and why it might be discounted.			

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 **Rice University/University of Houston**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
Rice University/ University of Houston	2019	2020	2021	2022	2023
	The CMS data e-lab because it will give students hand on and real life experience with current and relevant data. Students can connect with the forefront of science knowledge.		I plan to use QuarkNet activities at the beginning of the year with careers in physics. I plan to use the particle cards to introduce modern physics to students. We can use the mass of z with the cons. Examples: Mass of pennies, particle cards		Step Up Program, Coding Camps, and other activities. Examples: Careers in Physics, Histogram making, Particle physics Cards
	I teach both biology and physics but was primarily a biology teacher when I first learned about the e-lab. Having taught a year of IB physics I see a lot of opportunities to integrate the data activities in the classroom. In particular, the lessons that encourage students to derive relationships using graphical analysis prior to teaching the specific laws. This also provides a great resource for students looking to incorporate accessible and professional databases into their senior research projects in IB physics.				

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 **Rice University/University of Houston**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
Rice University/ University of Houston	2019	2020	2021	2022	2023
	Rolling with Rutherford and the Penny Lab			Personally I am using the coding skills I have gained to get students into coding with auxiliary lessons and tasks. I am currently being used as a biology teacher, so I have not been able to implement many of the activities in my classroom yet. However, I am able to provide better insight to students into what people in physics fields do.	
	"Mass of US Pennies" makes a great introductory lab exercise. "Calculate Top Quark Mass" is my most frequently used exercise.		I use the Data Activities at various times in the year especially when studying momentum and energy conservation. Examples: MASS OF U.S. PENNIES, CALCULATE THE Z MASS, CALCULATE THE TOP QUARK MASS	Case of the Missing Neutrino Energy, Momentum, and Mass Shuffling the Particle Deck. Examples: Mass of U.S. Pennies Shuffling thee Particle Deck Intro to Coding Using Jupyter Calculate the Top Quark Mass The Case of the Hidden Neutrino	Mass of U.S Pennies, Shuffling the Particle Deck, Calculating the Z Mass, Calculating the Top Quark Mass. They seem to be very useful for the students
	Mass of the US penny. I love how organized all of our activities are in the data portfolio with teacher and student resources and that I can pick the level and strand to use with my students. When planning my next year's physics class I will be able to use the portfolio to add several activities to my class.		I plan on getting my cosmic ray detector working and try doing some e-labs and masterclass. Examples: Mass of Pennies Shuffling the particle deck Making tracks 1.	This year I plan on incorporating histograms and coding into my classes. I plan on using simple coding with matching potion time graphs to have students graph motion. I will be also using the standard model and have a much better background for teaching it.	I have used the particle cards and the half life activities. QuarkNet has really helped my understanding of particle physics. I have done a masterclass with my students and I want to continue this for the next school year. As I get more comfortable with my new curriculum, I am going to try to include more QuarkNet activities.

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 **Rice University/University of Houston**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
Rice University/ University of Houston	2019	2020	2021	2022
	I have utilized several of the Data Analysis activities contained in the portfolio within my physics classroom. Rolling with Rutherford is an activity that provides students with the opportunity to use data they have generated for themselves, take measurements, and perform relevant calculations. The activity also provides students with the opportunity to learn firsthand how Rutherford made his influential discovery which resulted in our modern view of the composition of the atom.			
	Program Year (Year of Full Survey)	Subsequent Program Year		Subsequent Program Year
	2020	2021		2022
	I used the Rutherford model of finding subatomic particles in an atom and implemented Bohr model too.			Coding activities, neutrino activities etc. implemented python programing to calculate kinetics rate
	Program Year (Year of Full Survey)	Subsequent Program Year		Subsequent Program Year
	2021	2022		2023
	Rolling with Rutherford and mass of pennies.	I have incorporated Rolling with Rutherford with my chemistry students, particle deck, mean ½ life. Examples: Rolling with Rutherford, half-life, particle deck.		Rolling with Rutherford Energy momentum Mass Mass of penny Shuffling the particle. QuarkNet is valuable resource that I have used to improve my students ability to observe and analyze ata and draw conclusions.
	Haven't had a class to use it in yet.	Willing be using Shuffling the Particle Deck, Particle Transformation, Calculate the Top Quark and Mapping Poles this year. The opportunity to work with other teachers in great.		

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 **Rice University/University of Houston**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year
Rice University/ University of Houston	2021	2022	2023
	First year		Shuffling the particle deck - I introduce particle physics with this activity. Calculate the top mass -conservation laws
	Just introduced to them in this workshop so have not had a chance to implement.		
	Input data into spreadsheet for calculation and graphing.		
	Subsequent Program Year		Subsequent Program Year
	2022		2023
	Just introduced to them in this workshop so have not had a chance to implement		I need to look through these more. I know of them, but I am not familiar with any other than what I have done in workshop.
	Input data into spreadsheet for calculation and graphing.		Students use to make histographs to conduct data analysis. Data Activities are very useful tool to implement in the lesson delivery.
	Subsequent Program Year		
	2023		
	The Data Activities Portfolio gives students a new method of learning		
	First year. Using Colab is very applicable in the classroom.		
	Finding muon mass activities		
	The coding definitely is helpful as it gives me ideas on how to assess my students differently in lieu of the usual object test.		
	Ability to pull in actual research into teaching a topic. Example: radioactive decay activity. Well developed and easy to use 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.

Excerpt from a teacher's open-ended response to question about QuarkNet (as reported in fall 2023):

The big picture incorporated into science curriculum has a trickle-down effect on students and their life choices. We had a student that went to Masterclasses as an interest in this program through his classroom teacher and now he is a grad student at Rice in Physics.

Examples of Implementation Plan/Coding Projects Summer 2023

Table
Workshop Implementation Plans/Coding Projects Summer **2023**

Rice University/University of Houston Short Workshop June 19-21, 2023[a]		
Project	Title	Brief Description
1	Simulation of Radioactive Decay[c]	Using non-radioactive materials (e.g., dice, pennies) determine the probability of that nucleus decays over a given time period
2	Pullback Car Lab	Graphing position vs. time – difference in motion between pullback car and a buggy
3	Projectile Motion in Air	Lists of free falls to show how the air drag numbers differ.
4	Free Fall	Design a program to analyze the motion of a free-falling object
5	How fast? With coding[d]	Calculate how fast an object moves and observe the motion on a position vs. time graph
6	Calculating Pi	Understanding the difference between random and systematic error
7	Constant Motion	Measuring Distance and Displacement
8	Rebound Starman	How the solar system planets affect the orbit of the SpaceX Roadster over time.
9	Graphs: Changing axis and fit curves	Implementation plan under development for students to use in analyses
10	Graphing Position, Velocity, and Acceleration	Measure and plot the motion of a falling object
11	Homework	Creating a scatterplot in Python.
12	Hertzsprung-Russell Diagram	Coding project in progress
13	Collection of colab notebooks	A compendium of notebooks (over a 3-year period) including concepts such as Photometry, Kepler's 3rd Law, Plotting H-R Diagrams to compare groups of stars

Note. [a]As posted as of July 12, 2023. [c] Created by a pair of teachers. [d] Created by another pair of teachers