Center-Level Portfolio: University of Notre Dame

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 Notre Dame Center**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
University of Notre Dame	2019	2020	2021	2022	2024
	I have not reviewed those materials yet.	My Physics II class will be collecting data with the Classroom Cosmic Ray Detector and uploading the data. They may also be doing an e-lab or analyzing some LHC data. Examples: None yet - this is the first year for Physics II. QuarkNet provides a rich collection of resources and content to support teaching advanced physics topics at the secondary level.	Physics II students will use the classroom cosmic ray detector to study cosmic ray events, and indirectly relativity and the standard model. I have not used the activities. Most of our time in Physics I is classical physics and thus we don't have a lot of time to get to modern/particle physics. QuarkNet provides a great opportunity to stay in touch with the world of modern physics, and when the opportunities present themselves, I incorporate particle physics. I was planning to do several activities in the past three years, but because of schedule disruptions due to Covid, we ran out of time and I had to drop these activities. QuarkNet offers opportunities for practicing teachers to stay connected with recent developments in modern physics, as well as interact with other teachers in the same field. This has been very beneficial.	We do a unit on modern physics. We will use the classroom cosmic ray detector as an introduction into subatomic particle physics, getting to an understanding of the Standard Model. I was planning to do several activities in the past three years, but because of schedule disruptions due to COVID, we ran out of time and I had to drop these activities.	I will use the classroom cosmic ray detector when we discuss the standard model and relativity (i.e. lifetime of a muon). None, unless I have an independent study research student. There is just not enough time in the year to cover everything in the Physics I standards.
	Rolling for Rutherford (I actually teach chemistry)	Teaching freshman biology how to use python to make simple graphs.	N/A because I am not a physics teacher.		
	No experience with them.				

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University of Notre Dame	2019	2020	2021	2022	2024
	Rolling for Rutherford - in Integrated Chemistry/Physics to introduce models of the atom. I use histograms (and a Masterclass) in my Advanced Research Class. Showing uncertainty and data spikes and all the wonderful things you can see with this activity really helps students understand large groups of data. They have many levels of expertise. It is a great hands-on way for students to see how to work with a lot of data. Wonderful! I wish I had more time in the classroom to implement QuarkNet ideas and more time out of the classroom to develop my own teaching strategies and plans for it all. I can now talk about my own research to the students, the methods in general but often the difficulties, the uncertainty, and the fun I had with it.	I have done Masterclasses (2 different ones) after school for interested students, had an Advanced Research class student work with me over the summer doing QN research at Notre Dame, done a STEP Up. Examples: Mass of Pennies, Rolling with Rutherford, Dice Histograms, STEP Up, CMS Masterclass, Atlas Masterclass. Particle Physics sounds scary to students at first but they get over that and are pleased to learn new things.	I have a masterclass after school in the spring, add in some of the build up for it in the energy/momentum unit, and use QN activities like Rolling for Rutherford. Examples: Rolling with Rutherford, Mass of US Pennies, Calculate the Z mass. Being able to share my own forays into research has been very useful and possibly motivating for my students.	Conservation laws and momentum units in AP physics we helped by particle physics modeling. Examples: Rolling with Rutherford, calculating the z mass, cams data express, neutrino master class	I use it with vectors in math, and as examples on computer science. We use the particle physics examples to learn python with colab. Examples: Dice histogram and probability for an intro on probability. For quantum computing actually. Shuffling the particle deck last year, not sure about this year. Intro to coding using Jupyter (Colab). Modified. A masterclass - not sure which one this year but last year was MINERvA. Having a topic that my high fliers don't already know about is nice.
		I have used some of the e-Labs and data from the LHC in my particle physics unit in my high school physics class. I haven't used them as of yet, since our school has moved to virtual classes and I have not yet decided.			

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University of Notre Dame	2019	2020	2021	2022	2024
	I use the Particle Adventure Internet site with my ICP students. I have also used the "Mass of US Pennies" lab, and participated with Rolling for Rutherford at some of our public science outreach events.	I plan to use PhyPhot with my physics students. Examples: Particle Zoo, Exoplanet Masterclass, labs such as mass of pennies	I have used a cloud chamber and muon detector with my students. I have also used the Particle Adventure site with students. Examples: Particle Adventure, Exoplanet Masterclass	I have used a cosmic ray detector and cloud chamber with my students. I have also participated in an exoplanet masterclass and world wide data day. I have used particle adventure site with my students.	
	Rolling with Rutherford	Analyzing J/Psi data with students. Example: J/Psi Data			
	Mass of the Top				
	I used the mass of a penny activity and the top-Quark activity both after going to Data camp last year.		I use Cosmic Rays and the LHC talk about uncertainty and statistics. Examples: Mass of Pennies, Dice, Histogram, and Rolling with Rutherford.	I talk to students about our ability to create matter at the LHC when we talk about conservation of matter. I also include that there are more subatomic particles than Protons, Neutrons, and electrons. One of the biggest things I include is the nature of science research. Examples: I use Penny Mass and Rolling with Rutherford.	
	Collision exercises and the hadron cards				

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Self-reported Use of Data Activities Portfolio Activities: Based on Reponses from the Full Survey and then Responses from the Update Survey in Subsequent Years **University of Notre Dame Center**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
University of Notre Dame	2019	2020	2021	2022
	Quark Puzzle, rolling w/Rutherford, top quark, z-mass, penny mass. They are a great way to incorporate particle physics into what you already teach. QuarkNet has been a positive influence in my teaching career.	I use the Cosmic Ray muon lifetime lab using the detectors in my classroom, attend masterclasses, several data activities including dice, quark puzzle, rolling with Rutherford, top quark, z-mass. Examples: Dice and histograms, quark puzzle, top quark, z-mass, rolling with Rutherford. My QuarkNet experiences have always helped keep my teaching up to date and relevant. They provide a source of collaboration that is a continuous font of new ways to approach teaching challenges. They	I use QuarkNet activities from the Activity Portfolio, specifically: Z-Mass(Conservation of Momentum, Energy, Mass and Charge), D-Zero(Conservation of Momentum, Energy. Examples: Quark Puzzle Z-Mass D-Zero Rolling w/Rutherford Dice Half-Life.	I use my cosmic ray detector to introduce the standard model, time dilation, and exponential decay. I use the following QuarkNet activities from the data activities portfolio to reinforce concepts of momentum and energy and the standard model; z-mass; Rolling with Rutherford, quark puzzle. I also participate in World Wide Data Day, Cosmic Week, and international Masterclass. I have recently begun incorporating coding activities using CERN open data and Space-X rocket data. Examples: Rolling with Ruther- ford, Quark Puzzle, Z Mass, Mean Lifetime 1 and 2. My QuarkNet experience is a steady font of new information and inspiration that continues to guide and enrich both my own and my students' enjoyment and understanding of both traditional Physics and more contemporary ideas and discoveries in the ever changing and evolving discipline.

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Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
University of Notre Dame	2019	2020	2021	2022	2023
	The Cosmic e-Lab...I have a CRD in my classroom and it is was helpful to learn how to use the CRD with students.	My Physics II class will be collecting data with the Classroom Cosmic Ray Detector and uploading the data. They may also be doing an e-lab or analyzing some LHC data.	Physics II students will use the classroom cosmic ray detector to study cosmic ray events, and indirectly relativity and the standard model.	I was planning to do several activities in the past three years, but because of schedule disruptions due to Covid, we ran out of time and I had to drop these activities.	This (DAP) gives a good overview of how to collect data, analyze it, and present it.
	Penny Mass Rolling with Rutherford				Rolling With Rutherford. They are useful hands on activities used to illustrate concepts.
	Rolling for Rutherford - in Integrated Chemistry/Physics to introduce models of the atom. I use histograms (and a Masterclass) in my Advanced Research Class. Showing uncertainty and data spikes and all the wonderful things you can see with this activity really helps students understand large groups of data.	I have done Masterclasses (2 different ones) after school for interested students, had an Advanced Research class student work with me over the summer doing QN research at Notre Dame, done a STEP UP program. Examples: Mass of Pennies, Rolling with Rutherford, Dice Histograms, STEP Up, CMS Masterclass, Atlas Masterclass.	I have a masterclass after school in the spring, add in some of the build up for it in the energy/momentum unit, and use QN activities like Rolling for Rutherford. Examples: Rolling with Rutherford, Mass of US Pennies, Calculate the Z mass.	Conservation laws and momentum units in AP Physics we helped by particle physics modeling. Examples: Rolling with Rutherford, calculating the z mass, cams data express, neutrino masterclass.	My first Masterclass really opened my eyes to the level of understanding and learning my students could achieve. Rolling for Rutherford is useful in almost every class I have taught, from physics to math to Research to CS. I teach many different classes and it is important for me to have particle physics topics for all of them. It is easy to use and has helpful activities for a variety of classes and topics.

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Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
University of Notre Dame	2020	2021	2022	2023	2024
	I plan on using these activities more. With going virtual, we have to be more creative. I present to my Science Department the activities we worked on that might be useful in their classroom. The workshops are great and useful. Having this type of community is a great resource. Using the Cutting Edge science shows students modern physics instead of talking about classical physics. Great experience for the students.	When covering the conservation laws, I bring up LHC and how it applies to modern day physics discoveries. Examples: CMS Masterclass, Energy Momentum and Mass, Rolling with Rutherford. This is a great way to show students how true research happens. The concepts in physics are applied using up to date research in Particle physics.	The conservation laws such as Conservation of Momentum and Energy. I use these laws to explain how some of the subatomic physics are observed. Examples: I have not had time to use these activities in my classroom. I am hoping to make time this year to incorporate more of these activities Using more of the Data Activities would be helpful. I need to spend more time working on this process.	Making it around the Bend – Qualitative. Cosmic Ray Elab let's us study some cutting edge research in the origin of the muons	When explaining conservation laws, I use the High Energy Physics as an example e of where it is used. I will not have time to use any of these activities

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Center	Program Year (Year of Full Survey)	Subsequent Program Year
University of Notre Dame	2021	2022
		Students learn about the elementary particles form in the early universe. Examples: We cover a full semester every quarter, so there is not sufficient time.
	Program Year (Year of Full Survey)	
	2022	
	Rutherford experiment is very helpful to study the way of abysis.	
	Penny activity Rolling with Rutherford Mass/Energy activity Z Mass etc.	
	Data gathering, data comparisons, and identifying various variables based on the data collected.	
	Program Year (Year of Full Survey)	Subsequent Program Year
	2023	2024
	We did the masterclass as part of our physics classes	I am using Data Loggers with my science club and we are launching some sensors up in a weather balloon (among other experiences). I am not sure was the DAP is.

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.)

The next page presents data collected during a CMS Masterclass at the University of Notre Dame on February 28, 2023.

Masterclass: FNAL-28Feb2023
location: NotreDame2023