Center-Level Portfolio: Catholic University of America

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 under-standing 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 **Catholic University**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
Catholic University	2019	2020	2021	2022	2023
	Data collection and analysis.				
	I plan to use 6 activities from the Data file (*not specified*). I learned so much and was welcome to wonder out loud. A safe space for learning and growing.				
	We are going to be using the class tool to create a camp. Last year was too overwhelming for me to do a project on my own, especially since I do not teach physics, but this year we have the building tools to create a physics camp for Title 1 students.				
	While this was my first year at QuarkNet, I plan to implement much of what I have learned! I also hope to take an on-line Particle Physics I class.				
	Data Analysis: AP Statistics Univariate data analysis, numerical summaries, boxplots, histograms, hypothesis testing Trigonometry: 4-vectors, right-triangle trigonometry (close & form the right triangle), component-wise addition Intro. to Computer Science: This has the potential of using Python to analyze the data contained in .csv files				
	My first year at QuarkNet, I plan to implement much of what I have learned. (My focus is as a STEM teacher - after-school and non-school hours)				
	Use of tracker. Z mass				
	Dice Histograms, Shuffling the Particle Deck, and Rolling with Rutherford				

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Catholic University	2019	2020	2021	2022	2023	2024
	I have used the Mass of Pennies lab in chemistry previously for average mass determination. I have worked with something similar to the Mapping Magnetic Fields lab, but with electric fields and carbon paper. They are novel in scope and content, and might be not only a welcome change in those aspects for teachers but also a highly interesting topic for students!		Virtual Coding: From this activity, I want to pull in the coding-specific lesson design to my physics classes. I'd like to target on-level physics students with coding-based activities. Excited to use many of the histogram-related activities. I am also EXTREMELY excited to incorporate the STEP UP activities in my classroom and evangelize them to my department	Coding will come up in a big way in my AP Physics C classes this year. I intend to implement them as a standard way to do data analysis throughout the school yar. I hope to incorporate QuarkNet particle physics activities near the end of the year in my Honors Physics class. I also hope to incorporate some cross-curricular with our art department or marker space to bring particle physics forward in our community. I hope to use the Energy, Momentum and Mass activity (hopefully the quantitative version) with my AP students in this year. As time allows, I intend to use one or more of it Making It Round the Bend both in AP Physics but also honors physics at the end of the year when we reach magnetism.	Most recently the STEP UP Women in Physics activities were adapted for use in my physics classes. I have also used the Coding in Jupyter Notebooks to frame lesson design around coding implementation in Colab notebooks.	

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Catholic University	2019	2020	2021	2022	2023

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year 2023
Catholic University	2021	2022	
	Data is continually updated and data from new experiments is uploaded regularly		Data bases for use in creating analytical graphs and histograms// select e-labs adapted to grade // Quark Net presentations on cosmic rays and cosmic ray detectors
	None at present as this is my first year.		
	Mass of a penny; shuffling the particle deck; rolling with Rutherford.		

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year
Catholic University	2021	2022	2024
	Classes have not yet begun, e-Labs and the data provided will be of great use; understanding detector construction will allow a more thorough explanation of function of iPad cosmic collection apps.	In discussion of em radiations during space unit (grade 6) and energy unit (grade 7). These factors play a role in the units previously discussed.	incorporate concepts & adapted activities into middle school science, introducing the concepts. Examples: Pennies, Dice, Histograms, Quark Cards, Energy/Momentum graphing. It supplies me with a depth of understanding that I can adapt and incorporate into my middle school science courses, introducing these younger students to a more complete understanding of scientific processes and atomic structure.

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Catholic University	2022	2023	2024	
	I will. The program to present posters it will help the students with displaying the scientific method and presenting data.			
	Program Year (Year of Full Survey)	Subsequent Program Year		
	2023	2024		
	Use of data, analysis and graphing. Too advanced (DAP) but we can easily convert it to other topics we teach.			
	I intend to bring this learning and experience to my High School students so they can see the relevance of modern physics and find some real world connections with the content they learn in classroom.			
	I haven't had an opportunity to do some of the activities, yet. However, I do plan to attempt to do these activities in my AP Stats class this year. QuarkNet has contributed to my understanding of analyzing particle physics data; however, it is just that I have an extremely tight and regimented curriculum that does not allow for that much deviation.			
	QuarkNet has contributed to my understanding of analyzing particle physics data; however, it is just that I have an extremely tight and regimented curriculum that does not allow for that much deviation.			
	None yet, but I hope to incorporate more into my practice. Thinking of using What Heisenberg Knew, Mapping the Poles and Making it 'round the Bend. Good, reliable data and sources. Well thought out plans - teacher information as well as student information			
	Share it (DAP) within the school and county professional learning community. I thoroughly enjoyed this week long workshop. I intend to bring this learning and experience to my High School students so they can see the relevance of modern physics and find some real world connections with the content they learn in classroom.	I plan on using the following activities throughout the school year: 1) How Speedy are these muons 2) TOTEM 3) The case of the hidden neutrino. And will keep looking for and integrating more activities in my physics curriculum		
	No response	I intend to use the Data Activities Portfolio to expose my students to cosmic rays and magnetic fields. I plan on using Mapping the Poles as a lab during the first week of school.		

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 14 teachers.)

CUA Lesson Implementation July 2023

8th grade- Physical science- Teacher #1

<u>Goals:</u> Enduring understanding • Our understanding of the atom has changed over time reflecting the nature of science. • Atoms are composed of subatomic particles, each with their own location and characteristics. • The periodic table is a tool used to organize information about elements.	**Standard/ Unit:** Atoms (unit 3) and Periodic Table
How to assess learning? - Quiz/test using canvas - Group work & presentation - Construct and use models and simulations to represent the structure of atoms; evaluate the limitations of models used (PS.2 a)	**Guiding questions:** How has the atomic model changed over time and what role has technology played in it? Why do we need models of atoms and what are their limitations? What role does organization play in the design of the periodic table?
Learning Experiences:	1. **Partner discussion:** • What is matter made out of? • What is the smallest particle you know? • How do you think scientists have arrived at this knowledge? 2. **Presentation:** I will use and include pictures of our field trip- Videos: • The Standard Model of Particle Physics • Just how small is the atom? 3. **Group research:** Voyage through time…***Frayer Model Poster*** A. Greek philosophers B. J. Dalton C. J. J. Thompson D. N. Bohr (Chadwick) E. ______ **Differentiation:** quantum particles cards- research and exploration- JLAB, Fermi lab, etc Blog Mayan Muons and unmapped rooms 3. Construct a model or simulation to represent the structure of atoms- limitations • Tinkercad • Physical model • pHet lab

Video for Matter: Nature of Matter **unit 2**- also incorporates measurement, metric units and prefixes in the instrumentation and practices.
Unit 6: Electricity and Magnetism- practical applications- differences between electronics and electrical circuits.

- Science at home from Jlab- Electromagnets

Teacher #2

Physics Coding Module #4 - Particle Physics Datasets

Colab Notebook Link

Rationale

This module is intended to follow a basic introduction to using Python and Colaboratory notebooks to analyze large data sets and transfer those skills to work with large particle physics data sets.

Target Audience

This module is primarily for students in a physics course of any level. Differentiation within the module itself is accomplished through clarity in levels of difficulty.

Learning Goals

- Import CMS (Compact Muon Solenoid) data
- Create overlaid histograms to analyze data

Extension Goals

- Presentation and argumentation using data.

CUA Lesson Implementation July 2023

Teacher #3

Standard Learning Goals	Assessments	lesson/unit ideas
• Understand energy on Macroscopic as well as Atomic scale • Analyze momentum conservation • Data analysis by collecting data and graphing it • Make real world connections with particle physics	• Students will do some sort of data analysis from CERN data (I have heard it's available) • Perform muon detector lab (Cosmic watch lab, demonstrated by Ken) • Have students explore the activities from the Quarknet website. (showed by Ken)	These activities will be incorporated in units of energy, energy and momentum conservation, graphing and data analysis!! Show videos on Standard Model in particle physics Share the quarknet net experience, Jefferson lab presentation
If there's time … I would like to talk about the mayan pyramids and how the secret chambers are detected via cosmic ray detectors to address CROSS-DISCIPLINARY SKILLS		Show videos, share presentations

Teacher #4

12th grade - Research Practicum - Physical Sciences

Student learning Goals:

- Develop an understanding of the Standard Model in general, Muons in the context of cosmic rays in particular (using video(s)) and of muon tomography (using pyramid example → annotated bibliography)
- Be able to present data graphically (scatter plots, histograms) and interpret graph
- Be able to describe and calculate the mean of a set of data
- Be able to describe and calculate the measures of the spread of data (variance, standard deviation)
- Be able to conduct and interpret hypothesis tests for two population means.

Assessment:

- Application to data collected during a Physics lab in the previous year
- Ongoing

CUA Lesson Implementation July 2023

Teacher #5

Level	Unit	Goal	QuarkNet-related Activity
sc6	Astronomy Meteorology Geologic Time	1) identify evidence the existence of extraterrestrial sources of energy 1) Explain why the thermosphere affects the ability of life to live on earth's surface !) Use a model of radioactive decay to date samples	• Use om Apple app- muon detector to demonstrate existence of cosmic rays • "cosmic compass" would be more accurate: experiment to determine angle of particle source • Use of cloud chamber to illustrate paths of charge particles • Use of quarknet resource:**https://www.i2u2.org/elab/cosmic/content/CosmicExtremes.pdf** • **Adaptation of Quarknet lab https://www.i2u2.org/elab/cosmic/home/project.jsp** •

sc7	Energy
	
	Atoms
	
	Analysis of Data
		1) Describe the effects of magnetic fields on matter
		
		2) identify the properties of an atom's particles
		
		3) using histograms to analyze data
			• Introduction to particle detectors https://particleadventure.org/modern_detect.html
			• Demo- glass/plastic ornament with mystery objects inside-in zip lock baggie smashed against surface
			• Use of magnetic fields to control motion
			  ○ Demo- static charges' effect on flowing water
			  ○ Video: cathode-ray tubes (as in old TV)
			• Quark Net database for histograms:

sc8	Genetics	1)Explain the effects of radiation on the structure of DNA	•

CUA Lesson Implementation July 2023

Teacher #6

Introduction to Quantum Concepts

Unit	**After Unit Concept**	**Activity/Lab**
Kinematics	Nanotechnology	Nano Technologies https://www.youtube.com/watch?v=LUE7jCGQr1E
2D Kinematics	Cosmic Rays	Cosmic Watch Cosmic Ray Detector
Forces	Quantum: Superposition	Polarizers Intro to Waves Double Slit Experiment (with lasers and fog machine) https://www.youtube.com/watch?v=v_uBaBuarEM
Energy	Quantum: Historical figures and Energy Quantization	Photoelectric Effect Lab If You Don't Understand Quantum Physics, Try This! https://www.youtube.com/watch?v=Usu9xZfabPM&t=685s 9:24 "Where does the name 'quantum' come from?" Max Planck Einstein - Photoelectric Effect https://www.arborsci.com/blogs/cool/electroscope-photoelectric-effect
Momentum	Quantum:	The Standard Model https://www.youtube.com/watch?v=Unl1jXFnzgo
Circular Motion	Particle Accelerator Labs	Fermi Lab https://www.youtube.com/@fermilab CERN https://home.cern/ Thomas Jefferson National Accelerator Facility https://www.jlab.org/
Gravitation	Quantum: Uncertainty Principle	Heisenberg's Uncertainty Principle https://www.youtube.com/watch?v=qwt6wUUD2QI
Rotational Motion	Quantum Computing	Quantum Computing https://www.youtube.com/watch?v=lY3jhUhVxK0 https://www.youtube.com/watch?v=X8MZWCGgIb8 Interferometer?
Simple Harmonic Motion	Quantum Mechanics	MIT https://www.youtube.com/watch?v=lZ3bPUKo5zc&list=PLUl4u3cNGP61-9PEhRognw5vryrSEVLPr Professor Allen Adams

CUA Lesson Implementation July 2023

Modern Physics Course: Physics

A pacing guide is not included for this unit; teachers are expected to teach some of this material but not all.

STAGE 1 – DESIRED RESULTS	
Modern Physics Big Ideas (*concepts/themes*): complexity	
HRL Framework Components	
Enduring Understandings: *Students will understand that…* **(Intellect)**	**Essential Questions:** Students will answer the questions…
• The study of modern and non-Newtonian physics can be applied in varied technological applications. • Newtonian physics doesn't adequately describe phenomena at the extremes of small size or high speed. As modern physics has explored areas of extreme speeds and subatomic particles, new paradigms have been created.	• What are examples where Newtonian physics breaks down? • How do we know that wave particle duality must exist? • How do light waves differ from mechanical waves?
Students will know…	
From VDOE Framework	

The teacher should select areas based on student interest and their own understanding of physics concepts. Possible topics include:

- *wave/particle duality;*
- *quantum mechanics and uncertainty;*
- *relativity;*
- *nuclear physics;*
- *solid state physics;*
- *nanotechnology;*
- *superconductivity;*
- *the standard model; and*
- *dark matter and dark energy*

Modern Physics Course: Physics

Learning Targets: *I can…*	**Assessment Evidence (Stage 2)**	**Resources for the Learning Plan (Stage 3)**
evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described by either a wave model or a particle model, and that for some situations one model is more useful than another (PH.9 a, b) communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy (PH.9 a, b)	Formative Assessments: Summative Assessments:	Resources:
provide examples of technologies used to explore topics in modern physics (PH.9, b, c, d, e, f, g, h, i) compare classical physics and modern physics at the extremes of speed and size (PH.9 a, b, c, d, e, f, g, h, i) explore the connections between and the benefits of the pursuit of pure science and subsequent applications (PH.9 a, b, c, d, e, f, g, h, i)	Formative Assessments: Summative Assessments:	Resources: