A JOURNEY THROUGH EMPIRICA GUIDED BY DR. VERNET EATON

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Part I: Wesleyan Physics 1831-1925

In 1930 Wesleyan University employed two PhD physicists, and within forty years that number rose to sixteen.[1, 2] This drastic leap is reflective of the exponential growth that occurred in physics in the mid-twentieth century. The century saw the birth of new fields such as relativity and quantum mechanics, movements towards the laboratory and mathematical calculations, and sharp peaks in national demands for physicists. At a time when the United States was encouraging its physicists to "shut up and calculate," Wesleyan's Dr. Vernet Eaton also saw the need for advanced mathematical rigor in physics education, but desired to make his students think deeply and foster an appreciation of the beauty of physics. Physics at Wesleyan has drastically changed since its inception and Dr. Eaton helped mold it into its current state.

Wesleyan University opened its doors to 48 students in 1831 under President Willbur Fisk.[3] From the onset concepts of physics were taught, but under a different name. What we refer to now as physics once went under the name natural philosophy, and it was taught within the mathematics and natural science curricula. Professor Augustus Smith was the first to teach natural philosophy to Wesleyan students. He is known for teaching a course in mechanics (required for all students until the early 1870s) for which he developed a textbook.[3] When regarding Professor Smith's textbook in a 1927 address, Wesleyan Professor Morris Crawford stated:

> [Smith's textbook] was an excellent treatise covering the mechanics of solids and fluids. To attempt however, to require the study of this textbook of all students today would lead to an insurrection in comparison with which the worst strike ever contemplated against compulsory church attendance would be only a whispered protest.[4]

Professor Van Vleck became known for his work in the departments of mathematics and astronomy was the next to teach mechanics after Professor Smith. Much to the chagrin of some early Wesleyan students, Professor Van Vleck used Smith's textbook.[5]

For institutions of higher education in most of the 19th century emphasis on research in the sciences was next to none; any focus on research paled in comparison to that of education in classical studies such as language, history, literature, art, and mathematics. The 1870's saw a movement towards increased education in the sciences and for American universities to adopt the German model of higher education, which placed an emphasis on graduate research. Spearheading this movement was Daniel Gilman. Gilman graduated from Yale University in 1852 and later helped bring a scientific school to his alma mater before becoming the second president of the University of California, Berkeley. He had dreams of bringing a new age of scientific study and research to Berkely, but these ideas were dismissed as radical, and no such change occurred under Gilman's short tenure as president.[6]

In 1874 Gilman was offered a job as the first president of a new university in Baltimore. In their offer, the trustees made explicit that Gilman would have the ability to lead the university as he wished, with no obligations to the state as he had at Berkeley. The trustees had complete faith in Gilman after he had been strongly recommended as the best person for the position by the presidents of Harvard, Cornell, and Michigan.[7] In 1876 Johns Hopkins University was opened as the first American research university with Gilman at the helm, who was finally offered a chance to fulfill his research-laden dreams. Hopkins led the way in research in American universities at its onset, but other prestigious universities were quick to follow suit. President Eliot of Harvard was hesitant to make any significant changes at first because he had obligations to uphold the traditions of America's oldest university. However, once he started losing faculty to John's Hopkins who wanted to produce knowledge rather transmit it, he knew that change was necessary.[8] The founding of Johns Hopkins provided a catalyst for scientific research among American universities.

This opposition to laboratory research among universities is in line with the historical opposition between workers in *episteme* and *techne*. Workers in *episteme* studied scientific theory, while those in *techne* made advances in technical, hands-on work. This hands-on work included building scientific apparatuses and physically carrying out experiments. Many famous scientists of history did not bother to "dirty their hands" in the lab, they would have a group of lab technicians or assistants carry the work out for them instead (especially if it was dangerous). These early *techne* workers were rarely given due credit for their work.[9] The two have long been considered separate fields, and the current divide between theoretical and experimental physicists is a relic of this worldview that has existed since the time of Aristotle. For much of history, theoretical and technical work was kept separate, and when they did intertwine the "scientific gentlemen understood the relationship as one of master to servant."[9] So institutions of higher education were hesitant to encourage their students to pursue a line of work (experimental science) that has long been thought of as inferior. This ideology was maintained until excellence in scientific research began to raise the prestige of a university in the 20th century.[6]

Faculty members at Wesleyan took part in this scientific movement and in 1873 pushed President Cummings for an increased amount of scientific and laboratory study. As a result, in that same year the first "physics" class was offered and made required for all students (and remained required until 1908). Additionally, Wilbur Atwater who "is generally credited with creating the atmosphere of research on the Wesleyan campus," was hired in that year.[10] Then the following year Morris Crawford graduated from Wesleyan. Crawford was brought in as

Wesleyan's first instructor of physics in 1880, and later became promoted to Wesleyan's first professor of physics in 1884. While he did not conduct any research, Crawford was known as a great conductor of lecture demonstrations. He was considered, "a man of the highest integrity … with a good command of basic physics."[11] In 1881 Crawford taught Wesleyan's first physics laboratory class; at the time, the offering of a laboratory class was a notable achievement in the expansion of a department.[12]

1890 was another year of notable expansion for the physics department with the addition of an electrical lab. The opening of the electrical lab allowed Wesleyan the opportunity to provide an advanced study of electricity to its students. There was a caveat however, the trustees did not want the laboratory to be used to teach electrical engineering courses. They wanted only to offer courses in theoretical and applied electricity.[13] In 1891, Wesleyan looked to hire a new member of the physics department to make full use of their new electrical lab. Their top candidate was Dr. Edward Rosa, who graduated from Wesleyan in 1886. After Wesleyan, Rosa went to Johns Hopkins to pursue his PhD in physics. While at Hopkins, Rosa produced "work of such high quality that almost at once it raised him to a level of a prominent American physicist."[10] So naturally Rosa had many attractive job offers, even one to remain at Hopkins as an instructor.[4] Wesleyan was able to "steal" Rosa from the other prominent universities looking to hire him, a truly influential hire for Wesleyan. With the addition of Rosa as an associate professor, the physics department became the first at Wesleyan with two full professors and quickly rose to be one of the university's strongest departments.[10]

Much of Rosa's early work involved the electrical laboratory, where he taught courses such as electricity, elementary applied electricity, mathematical theory of electricity, alternating currents of electricity, and more.[14] Rosa's expertise in electricity and willingness to teach it propelled Wesleyan's status in the field. In addition to his pedagogical obligations, Rosa also conducted research with Atwater, helping with the creation of the respiration calorimeter.[10] Rosa was a key factor in the rise of the Wesleyan physics department, but his stay was shorter than the university would have liked.

Both Rosa and Atwater pleaded with the university to further engage in and fund scientific research, they both saw it as a next step in the advancement of Wesleyan as a top-tier university. Atwater wrote to the trustees saying:

> We could … be able to take the lead among the educational institutions in the United States in this special line of higher research. This would be exactly parallel to what the best institutions around us are doing. It ought to make our laboratory a place to which graduates of other institutions as well as our own would be attracted.[15]

This attitude reflects the highly competitive atmosphere in scientific research that remains prevalent today.[16] Wesleyan did not take much action to address this during Rosa's time. When he saw nearby schools such as Yale, Harvard, Williams, and Amherst constructing state of the art physics laboratories, he was not pleased. This displeasure was surely exacerbated by the fact that the Wesleyan physics department operated in three different locations at the time, with the two main buildings (observatory hall and electrical lab) being across campus from each other.[11] Occasionally having to transport equipment cross-campus consumed time and energy that would have been put to better use had there been a central location for the department.

In 1901, Rosa was offered a job as the chief physicist for the newfound National Bureau of Standards in Washington, D.C. The attraction of an exciting new position combined with Wesleyan's lack of plans for a new physics building, and possibly Rosa's falling out with Atwater in 1898 (stemming from Rosa not receiving due credit for his work), led to Rosa's departure from Wesleyan in 1902.[4, 11] Rosa helped Wesleyan find his replacement and was keen on Dr. Walter Cady. Cady had studied abroad at the University of Berlin, receiving his PhD in

1900. So like Rosa, Cady was familiar with the German system of graduate research. In 1902 Wesleyan had its second chance with a premier research physicist with the hiring of Cady, and this time they were going to make the most of it. One year after Cady's hiring, Wesleyan trustee Charles Scott and his son Charles Scott Jr. offered to fund a new physics lab.[4]

Wesleyan hired architect C.A. Rich for the project, Rich was an experienced architect who had recently designed Dartmouth's new physics lab. After collaboration among Scott, Rich, Crawford, and Cady a final construction plan was reached, and the building was opened in 1905 where it would house the physics department for decades to come.[11] Dr. Rosa returned to Wesleyan to speak at the dedication of the new building and seemed delighted that the university was taking a step for the better in the realm of physics. At the dedication Rosa remarked:

> The dedication of a large and well-appointed building to be devoted exclusively to instruction and research in physics is a notable event in the history of a college. In this instance it is the realization of a hope long cherished by many, and by none more than by the present speaker.[17]

Dr. Cady was also quite grateful for the construction of the new laboratory, as he was initially uncertain about Wesleyan because the physics department was scattered across three buildings. The general atmosphere of Wesleyan and the personality of Dr. Crawford drew him in, but it was the construction of Scott Laboratory that made him stay.[11]

Around the time of the opening of Scott Lab, there began a movement among physics educators nationwide. The "new movement" as it was called, was brought about to combat the way physics was currently taught and make introductory courses "more interesting and inspiring to students."[18] This movement came to because some educators believed that the current teaching methods at the introductory level led to mindless "cookbook" lab exercises and memorization of concepts rather than understanding. The movement began targeted at the high school level and support for its validity was shown in high failure rates (61% of examinees) on the physics exam made by the College Entrance Examination Board.[19] The new movement then made its way to universities, who every year are tasked with the decision of how to teach their introductory classes. Wesleyan physics professor Dr. Paily acknowledges that this decision is a difficult one, as there are many topics that can be taught at the introductory level, but not nearly enough time to cover them all. The instructor must cover the essential topics in physics that provide the foundation for further study, however professors must also spend sufficient time on applications of physics because not everyone in an introductory class wants to further pursue the subject.[20]

This task of properly dividing the content of an introductory class between emphasizing the fundamentals of physics and applications of it has always been an issue for educators. In the 20th century two main schools of thought emerged. The first was mainly composed of high school teachers, and they advocated for students to be taught the real-world applications of physics.[19] Their focus was primarily on how different manmade technologies worked, without an in-depth introduction to basic physics. Plenty of high school educators did not regard physics as highly as physicists do, which should come as no surprise, but some even went as far to say, “science is a cold, impartial presentation of fact. It fails to stir the emotions, to stimulate the will.”[19] The second group was comprised of mostly university professors and physicists, who favored the teaching of the fundamental concepts of physics and principles of scientific reasoning. Their group saw physics as a beautiful and interconnected subject and believe that this beauty is lost on students when they are only presented with applications, which can at times be seemingly unrelated to one another. They also thought that mostly focusing on applications put students at risk of falling back into the trap of a rote memorization of topics, rather than a deeper understanding of them.[19]

Wesleyan's physics course offerings show that the department was impacted by this new movement among physics teachers. Dating back to the 1880's Wesleyan had offered courses such as "elementary practical physics" and "practical physics," which were laboratory classes, some of which were intended for those who wished to pursue teaching. Some of them consisted of "exact measurements in mechanics, heat, sound, and light."[21] Emphasis on taking exceptionally precise measurements was widespread in introductory physics education in the late 19th and early 20th centuries. A few decades later, after the new movement had run its course, those courses had been phased out of the course offerings and replaced by the addition of a laboratory period to the introductory physics course and a course in "experimental physics."[22]

Not only were course offerings changing in the early 20th century, but Wesleyan as a university was also expanding. There was a sharp increase in enrollment, the number of students increased by nearly 50% (340 to 504) from 1909-1910 to 1915-1916 alone.[23] This general expansion and increased enrollment made some class sizes larger than some professors liked. So, to address that issue on behalf of the physics department, Wesleyan hired Dr. Wallace Powers in 1919 as the third member of the physics teaching staff.[24] When Professor Crawford retired in 1921 after a lengthy and impactful career, he was soon replaced by Dr. Karl Van Dyke (Wesleyan class of 1916) who went on to have an extended stay at Wesleyan himself.[4]

Heading into the quarter-century mark the Wesleyan physics department, despite being smaller side, was quite successful at producing future physicists and engineers.[24] The department's goals were to "meet the needs of all students, whether they are looking forward to a scientific career or not," and for those who desired a career in physics, "furnish such a course of study as will best fit them to begin graduate work in one of the larger universities."[24] Preparing students to become quality physicists was a chief goal of the department. A good physicist can properly conduct experiments, take high-caliber data, and effectively communicate their results to the scientific community. When Dr. Powers left Wesleyan in 1925, the department then hired Vernet Eaton, whose dedication to his students and expertise in laboratory education and lecture demonstration, was nearly perfect for training physicists. Dr. Eaton proved to be one of the best physics educators of his time and was beloved by students and faculty alike.[25]

Part II: Dr. Vernet Eaton

Vernet Eller Eaton was born in Castleton, Indiana on December 25, 1895 and had dreamed of becoming a teacher his whole life. His dreams came true when he began teaching in the Indiana public school system in 1913 at the young age of 17. He taught there until 1917 when he began his service in the US Army, which lasted until 1919. He received his BA in physics from Indiana University in 1921, and then began work as an instructor at Williams College, where he would work until being hired by Wesleyan in 1925. During his time at Williams, he received his MA in physics, also from Indiana University. Eaton began his career at Wesleyan as an instructor and was then promoted to an assistant professor in 1927. In 1931 Eaton was awarded his PhD from Indiana University for his work on the physics of surfaces and thin films.[26] While Professor Eaton conducted research in his time at Wesleyan, his real passion was, as it always had been, teaching. His students could certainly tell, as Dr. Eaton remarked on multiple occasions that “the highest compliment ever paid to me by a student was that I seemed to enjoy my own lectures.”[27]

Dr. Eaton was best known for his work in introductory lab education and demonstration lectures; his excellence in these specialties eventually garnered him national recognition. His contributions to introductory lab education came in the form of the writing of two books, participation in and leadership of national conferences, correspondences with colleagues, and countless hours spent working with students.[26] He solo authored *A Laboratory Course in College Physics* (1935) and co-authored *Selective Experiments in Physics* (1939). The aspect of the introductory lab that he believed to be the most important was “experience with and appreciation of the various methods used in experimental science,” because it could not be replicated anywhere outside of the lab.[28] The only place to get hands-on experience with experimental science is the laboratory, and this experience is often lacking in first-year students. Therefore, getting students in the lab as soon as possible is best for their development as potential physicists. Introductory lab training also has benefits for those not interested in a career in physics. In my interview with Mr. Miglus, he remarked that even today there are a surprising number of students that he sees struggle with basic practical skills such as using a screwdriver and plugging in wires.[29] Lab experience allows these students to gain practical life skills while still exposing them to physics.

A key component of Dr. Eaton's laboratory education methods is the challenging of students in the lab.[27] Many introductory labs are "cookbook" in the sense that they provide a specific set of instructions for students to follow. Those types of labs don't require much thinking and are easy for students to complete. Dr. Eaton wanted students to be forced to think in the lab and not have everything handed to them. He wanted students to be intellectually challenged in the lab; he saw lots of value in learning by experience. This approach can be seen in his laboratory course books, and Dr. Eaton even gained a reputation on campus for how he pushed his students.[25, 30] Dr. Paily agrees that challenging students in the lab is a great way to help them learn but concedes, as Dr. Eaton does, that this is a difficult task for instructors.[20, 28] Most students come into the lab with no familiarity of the equipment or experimental methods, and they are just beginning to form a conceptual understanding of the topics at hand. So, it is challenging to devise a lab that is difficult, but not so much so that the students become lost and lose interest. Once students do have familiarity with the equipment and a solid grasp of the concepts and experimental methods they can be thoroughly challenged.

In my interview with Dr. Paily we discussed his vision of an ideal laboratory exercise, and his thoughts bore a close resemblance to Dr. Eaton's. Dr. Paily stated:

> So ideally, I suppose what you would want is a lab where you just give the most minimal amount of instruction. You give them a goal and the equipment. They need to figure out themselves how to use the equipment, and how to use it to implement that goal.[20]

Such a lab was what Dr. Eaton envisioned: given only equipment and a goal, students must become physicists and think critically for themselves. Dr. Paily admitted that this type of lab is better suited for upper-class students as they will have a better knowledge of physical concepts, more familiarity with lab equipment, and more of a willingness to struggle through a challenging problem than introductory students. However, inspiration can be taken from this and applied toward the introductory labs.

Part of the reason why Dr. Eaton emphasizes that students should be challenged in the lab is because he wants them to experience being an experimental physicist.[27] Dr. Eaton sees experimental physicists as artists, and like artists they are not given cookbook-like instructions to produce their work. Physicists overcome many frustrations and challenges along their way to understand the natural world and Dr. Eaton wanted his students to share in that experience. In his efforts to give students experience as physicists, he had them all maintain detailed laboratory notebooks, just as experimental physicists do. Dr. Eaton requested a high level of detail out of his students and wanted their notebooks to be something they could take pride in.[30] He was also keen on improving students' graphical skills because "whenever possible, a practicing scientist plots his data on a graph and draws his conclusions from this graph."[28] In addition to graphical understanding, Dr. Eaton maintained that students should also have to gain experience deriving equations because doing so is a common scientific practice.

In addition to giving students experience as physicists, inspiring an interest in physics was always at the top of Dr. Eaton's mind when it came to laboratory education. In the preface to his 1935 book *A Laboratory Course in College Physics* he stated:

> Considerable care has been taken in the choice of experiments in an effort to arouse in the students an interest in experimental physics.[30]

He saw physics as a beautiful and fascinating subject and wanted his lab exercises to reflect that. Dr. Eaton knew that students will be much more inclined to put effort into a lab they find interesting or exciting than one they already know the results for. While speaking to his fellow members of the AAPT he said:

> I would like to make a plea that students not be asked to check the validity of laws that have been checked by generations of students and always found to be true. This is not only a deadly experience and a waste of time, but it gives a false impression of the kind of thing a scientist really does in his laboratory.[27]

This thinking further explains his reasoning for the exclusion of "familiar" lab exercises from both of his course books. In his labs, Dr. Eaton wanted to challenge students, while also piquing their interest in physics.

Dr. Eaton likened his laboratory training methods to having students explore a foreign land he called "Empirica," which is inhabited by these strange creatures called "scientists."[28] He posed that there are three methods to exploring this land. The first is reading about it, like one can read a physics textbook. The second is to take a guided tour of Empirica, which he likened to learning via a demonstration lecture where the demonstrator serves as the tour guide. The third is to go native, to get students into the laboratory. One gains the most complete comprehension of Empirica when living among the native scientists. By learning how they use their tools, seeing how they plan and work, and experiencing firsthand their emotions of anxiety, frustration, surprise, and elation one gains an understanding of Empirica.

While living among the natives of Empirica one must be attentive and well-aware of their surroundings. One cannot have lapses in focus, or they may be at risk of missing something interesting. Dr. Eaton encouraged his students to remain alert in the lab and pay attention to detail in their observations. While speaking at the Conference on the Training of Graduate Student Laboratory Assistants in College Physics in 1954 Dr. Eaton told his peers:

> I think that this element of surprise and learning to be alert to surprising situations when they arise is an important part of laboratory experience.[28]

There have been many discoveries in the history science that have been “accidentally” achieved as the result of attentive observations.

An exemplary case would be that of Danish physicist Hans Oersted in his discovery of the link between electricity and magnetism. Oersted was known for his work in demonstration lectures, creating many experimental demonstrations for the Danish academy. During one of Oersted’s lectures he ran an electric current through a wire and saw that the needle on a compass nearby had moved, thus establishing a connection between electricity and magnetism.[31] While Oersted had been searching for a link between electricity and magnetism in the years prior, it was his attentiveness to his surroundings on that day that proved to be crucial in his discovery. Oersted’s discovery led him to further pursue the connection between electricity and magnetism. His contributions to the field helped set up the work of other famous physicists in the history of electromagnetism such as Andre-Marie Ampere, Michael Faraday, and James Clerk Maxwell. This work along with his excellence in teaching gave rise to Oersted’s fame among physicists.

There are currently multiple highly distinguished awards in his namesake, one of which is given annually today by the American Association of Physics Teachers (AAPT). The AAPT was founded in 1930 by university physicists who had a special interest in education. A few years after their founding they came to the realization that great physics teachers generate more physicists. So, they planned on creating an award for excellence in physics education to motivate physics professors to become better at, or put more effort into, teaching. Those in consideration for the award are nominated by their peers, with the AAPT ultimately deciding on the winner.

The Oersted Medal is the AAPT's oldest (first awarded in 1936) and most prestigious award, and it has been conferred upon some of the most famous physicists of the century such as Robert Millikan, Arnold Sommerfeld, and Richard Feynman.[32] On January 28, 1955, the Oersted Medal was presented to Dr. Eaton for his "notable contributions to the teaching of physics."[27] Those who had never heard of Dr. Eaton were likely surprised that such an award was given to a professor at a small liberal arts college. However, to those who got to know and work with Dr. Eaton, this honor was demonstrably fully merited.[33]

His work in the advancement of introductory laboratory education was not the sole reason for this honor, Dr. Eaton was known by his students and peers alike to be a first-class demonstration lecturer. He likely would have referred to himself as a "showman" or "performer" while he was lecturing. This mentality is rooted in the history of the demonstration lecture. Demonstration lectures have been performed since before the time of the enlightenment, but those who performed them were often not regarded as scientists. The lecturers would put on shows with their suite of demonstrations, while the work of theory and natural philosophy was left to those at universities. Many of these lecturers "played the part of purveyors of public entertainments," and were known for their abilities to captivate an audience.[34]

A characteristic of top-tier performers is being exceptionally well-prepared beforehand, and Dr. Eaton was no stranger to this notion. A key component of this preparation is the repeated practicing of demonstrations, because for the desired learning to take place the demonstration must not fail. In addition to many hours spent practicing demonstrations, Dr. Eaton kept extremely detailed lecture notes for himself.[29] These notes helped him run his lectures smoothly and allowed him to keep his focus on his students. Considering all the hard work Dr. Eaton put into his teaching, it is no surprise that he was an excellent demonstrator.

Dr. Eaton's many years of teaching experience also served to help him over his career. With his teaching career beginning at the age of 17 in 1913, he already had a decade of teaching experience by the time he arrived at Wesleyan. Over time he was able to see which demonstrations students favored and which ones helped them understand concepts better. Throughout his career he was primarily involved in teaching introductory courses and labs, aside from occasionally teaching electricity and magnetism and notably being the first physics professor at Wesleyan to teach a course centered on quantum theory.[35] While he taught the same material for decades, Dr. Eaton wasn't dragged down by the monotony. In his own words Dr. Eaton considered teaching "almost too much fun to get paid for," and each year he was provided with a new array of faces that would light up when he performed his demonstration lectures.[29, 36]

In his demonstrations Dr. Eaton preferred to use the simplest equipment possible. This was not because he was uncomfortable with expensive and complicated equipment, but because a simple apparatus allows the focus to remain on the physics, not the equipment.[37] Using such equipment also implies that basic physics is accessible to anyone, that one doesn't need convoluted equipment to grasp the fundamentals. Dr. Eaton believed in this idea so much that when he hosted the Wesleyan Conference on Lecture Demonstrations in 1959, he asked participants beforehand to come ready to:

> perform one or more experiments with a piece of apparatus of his own selection that cost less than a dollar and could be demonstrated in less than two minutes.[37]

In doing so he wanted to show all conference members the power and effectiveness of a simple demonstration.

As a good showman, one of Dr. Eaton's goals while demonstrating was to grab and keep the attention of his audience throughout the lecture. When speaking about this is in his Oersted Medal lecture he said:

> The men in this audience will remember that, when a certain girl in the chorus line smiled, she smiled directly at you, and you refused to face the fact that every other man in the theater felt the same way. Similarly, each student in the room must feel that the lecture is directed at him personally. Conversely, he must feel drawn into the lecture and feel a part of the act.[27]

He believed there were many ways to draw students in such as inviting them to guess what will happen next or bringing up a student or two to participate in the demonstration. Once the demonstrator has secured the full attention of the audience, just as a smiling chorus girl once did, they can make use of the element of surprise. Many of the predictions of the audience should be incorrect as the result ought to be a surprise; an easily predictable demonstration is much like an easily predictable show, boring. By seeing that their prediction was wrong, the student is provoked to think further about the physical concepts at play. The element of surprise makes many physics demonstrations memorable for students, and as Dr. Eaton would say, "a well-demonstrated physical principle seems to be almost unforgettable."[27]

The demonstration lecture has been a valuable teaching mechanism for educators for centuries and is still considered crucial for introductory physics education today. Demonstration lectures can serve many roles, but current Wesleyan professors Dr. Etson and Dr. Paily agreed that their most important function is helping students explain phenomena.[20, 38] Dr. Etson notes that lecture demonstrations are crucial in the mechanics portion of an introductory course as:

> People come into an introductory mechanics class, and they already have a framework of how they think motion works, and it's usually not a Newtonian framework … So, a lot of what you want to do in an intro mechanics class is get people not to learn something, but to unlearn stuff that they didn't have correct. So, you have to get people to change their minds, and you don't change your mind if you're not forced to consider whether or not you think a thing is correct. So, a lot of the stuff that you want to do in that class is aimed at both making someone become aware of what they think, and then realize 'oh, actually that's not right.'[38]

The use of lecture demonstrations forces students to think critically and evaluate their own conceptions of physics. When students can better explain phenomena and understand their own reasoning behind it, they become better at spotting flaws in faulty physical arguments. These skills help students become better equipped to effectively communicate and critically evaluate scientific results, which Dr. Eaton would agree is what good scientists do.

There are also layers in understanding a lecture demonstration. At the most basic level, demonstrations can be exciting to watch. Students can see something exciting or surprising happen and may be interested in learning more. Dr. Eaton would consider this to be the appreciation of the surface-level beauty of physics. The next level up comes with gaining a qualitative understanding of the phenomena. This is the level instructors hope their introductory students reach. At this level, demonstrations can be used as a clarification tool for some more challenging concepts, and students may start asking questions like 'what happens if we change …?' as they attempt to grasp an understanding of the physical principles. Therefore, Dr. Paily described the best kind of demonstration as:

> Simple enough that [students] don't have to just accept it, or 'that's the way it is.' And they can come up with a modification, and its simple enough that you can implement that modification right there.[20]

In that type of demonstration students can experience immediate clarity and solidify their knowledge of physical concepts.

The highest level involves both a qualitative and thorough quantitative knowledge of the phenomena. Not only will students be able to explain what is happening with words, but can numerically or analytically lay out what is going to happen beforehand. This level mostly occurs in upper-level classes where the professor chooses devote time to a particular demonstration. For example, in Dr. Paily's advanced course on classical mechanics students were shown demonstrations in class and then assigned homework problems on them. They had to both derive equations of motion for elements of the system using the Lagrangian and Hamiltonian formalisms and explain in words what was going on. After submitting their homework assignments, they were then shown the demonstrations again, this time having a further appreciation of the physics at play.[20] This level is where Dr. Eaton would say students get to appreciate the complete beauty of physics, now having a qualitative and mathematically rigorous understanding of the already fascinating phenomena.

A major trend in post-WWII physics education was the overemphasis on mathematical calculations, which came at the expense of a deeper conceptual understanding. This trend was exemplified in the new and exciting field of quantum mechanics; after the war quantum mechanics textbooks significantly decreased their focus on conceptual questions, while drastically increasing their mathematical complexity. Historian of Science and MIT professor David Kaiser writes on the subject:

> [Leading textbooks] contained homework problems–aimed at entry-level graduate students–that would have stumped leading physicists only a decade or two earlier … For every additional calculation of baroque complexity that physics students tackled during the 1950s and 1960s, they spent correspondingly less time puzzling through what all those fancy equations meant – what they implied about the world of electrons and atoms.[39]

This tradeoff does not allow for students to gain any further appreciation for physics aside from its mathematical capabilities. These generations of students missed out on wrestling with some of the truly fascinating conceptual questions quantum mechanics has to offer.

This development to turn physicists into calculators was only intensified when the Soviet Union successfully launched Sputnik into orbit on October 4, 1957, giving them a leg up in the space race. The demand for physicists in the United States was already at an all-time high after WWII with the onset of the Cold War. The launch of Sputnik only intensified the newfound demand for physicists and led to the US taking many measures to "gain ground" on the Soviet Union in the space race. One of these post-Sputnik initiatives was to educate as many people in physics as possible by means of a television program called Continental Classroom. The show was described as:

> A coast-to-coast college-credit course in Atomic Age Physics which represents a joint effort by a national television network, professional educators, industry and foundations to upgrade science teaching in America.[40]

Television lectures were held at 6:30 am, half an hour a day for five days a week on NBC Network. 250 colleges and universities offered credit for the course in Atomic Age Physics; the course also attracted interest from high school teachers and students, engineers, and many others who were curious about physics.[40]

When planning for the show first began, NBC combed the United States' top universities looking for the best physics educators to help manage the show. They chose Dr. Harvey White from the University of California Berkeley to be the face of the show. Dr. White was an experienced professor and had also contributed to national defense research during WWII.[40] NBC also hired Dr. Eaton as a consultant for the program, he worked alongside Dr. White forming the curriculum for the show as well as giving guest lectures himself on the topics of "polarized light" and "optical activity."[41, 42] While the physics portion of the Continental Classroom series was short lived, only airing for one season, it provided Dr. Eaton another opportunity to do what he loved: teaching people physics.

Dr. Eaton's legacy not only comes from his outstanding teaching career, but also from his outreach and preservation efforts.[29] Wesleyan owes many thanks to Eaton for its current inventory of introductory lab and demonstration lecture apparatuses. The inventory is currently maintained by Mr. Miglus, Wesleyan's curator of physics. While he does a great job of maintaining the collection himself, he insists that Wesleyan's collection would not be what it is today without the hard work of Dr. Eaton. Plenty of the items still used today were either acquired or made by Dr. Eaton, which he then subsequently preserved for future generations.[29] When rummaging through the storage rooms one can tell which items were surely used by Dr. Eaton, as segments of them are taped black and white. This taping was not because he frequently broke equipment, rather the tape was used to create contrast while Dr. Eaton was lecturing on TV for the Continental Classroom. Since TV was black and white, he needed a way to make his phenomena stand out while demonstrating, this was achieved by the black and white tape.

Over the course of his career Dr. Eaton impacted countlessly many people from the decades of students he taught, his peers at the numerous conferences he attended and led, and even those who tuned in to watch him and his colleagues on Continental Classroom. He left a lasting impression on Wesleyan University in particular, preserving a variety of educational equipment as well as changing the ways in which we introduce students to the wide-ranging and ever-growing field of physics. In a time of great change for the field, Dr. Eaton was able to remind students of what physics really was. As he said to close his Oersted Medal lecture:

> Physics is based upon mathematical rigor, irresistible logic, and sound architecture. We should not forget, however, that it also includes beauty, imagination, and drama. When these ingredients are properly mixed, the result is a truly exciting experience.[27]

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