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A Review of High School Physics Education in the United States of America

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Abstract: Physics is often considered to be one of the most difficult subjects to study. Thus, it is particularly important to have good physics teachers to teach the subject. However, a close look at the statistical data indicates that about 67% of high school physics teachers did not major in physics. Physics is being taught by teachers that are in variety of subjects, mostly another science and math. In addition, two-third of the 27,000 physics teachers teach other subjects than physics. Quantitative/Qualitative assessments and reasoning are made about the statistical data. Potential reasons for the current statistics and consequences are discussed. In addition, lack of mathematics background in the freshman and sophomore years of high school appears to push the physics classes towards junior and senior years, taken as an elective, or not taken at all. High school curriculum, teacher training and salary issues are also discussed.

Keywords: Physics Education, High School Physics Education, Science Education, Physics Teachers

1. Introduction

One of the most daunting challenges current university physics teachers face is how to inspire students, catch their imagination and fire their spirit for more exposure to physics, experimentation, and the exploration of new and yet uncharted horizons. The challenge faced by high school and middle school teachers is not entirely different. At the primary school level, children invariably have enormous imagination and curiosity for science and new knowledge. This imagination and curiosity appears to be more channeled towards biology and mathematics in the high school level, but no so much towards physics. In this article, the author tries to address the reasons for the channeling towards biology and mathematics by analyzing the statistical data and also the physics curriculum of high schools.

Physics education research has been trying to understand how students learn physics [1-6] for many decades. However, the focus of research has been in more of the aspect of learning. The conditions that are conducive to learning also needs to be addressed. More than twenty years of statistical evidence show that the majority of the high school physics classes are being taught by teachers who did not major in physics. This may be affecting the enthusiasm and quality of the physics education that high school students obtain. The proof of it lies partly in the lack of physics knowledge, low physics test scores and the dwindling number of physics students in colleges and universities across the United States. There are other factors effecting high school physics education as well, such as high school physics curriculum, deficiencies in mathematics background, school budgets and teacher salaries.

The method used in this review is to gather statistical data from various resources and analyze them. Some of the resources used are U.S. Department of Education National Center for Education Statistics, American Institute of Physics, and American Journal of Physics. Private communications with the surrounding high school students, parents and teachers provided really important curriculum information and motive for this article. National Public Radio (NPR), Public Broadcasting Service (PBS), and American Physical Society online resources provided some of the historical facts. Peer-reviewed journals such as “Physical Review Special Topics (ST) Physics Education Research” and “Science Education” helped understand the scientific practices and difficulties in physics teaching and learning. The author gathered information by inquiring from the current students in his physics classes. Most of these students are graduate of surrounding high schools and shared their high school curriculum information and their experiences with physics teachers in those schools.

The author also analyzed the Science Education Standards for high schools in Kansas. Kansas uses “Qualified Admissions” which are a set of standards used by the six state universities to review applications for undergraduate admission. These standards are set by the governing body for the state universities (Kansas Board of Regents).

2. Quantitative Analysis

According to American Institute of Physics, Statistical Research Center [7] the percent of high school physics teachers with a physics major is on the average 23% and with a physics education major is on the average 10 % since 1993. This means only about 33 % of all high school physics teachers have majored in physics/physics education for the last 20+ years. It also appears that physics teachers with a minor in physics or physics education is about 12 %. The cumulative proportion of physics teachers with a major or minor in physics or physics education has decreased from about 47% to 40% since 2001. This simply means more than half of physics educators are not career physics teachers. However, 73% of biology classes and 70% of mathematics classes are taught by a teacher with a degree in the subject [8]. In addition, not all the physics teachers with a major/minor in physics/physics education teach only physics. Two-third of the 27,000 physics teachers teach other subjects than physics. [7]. This suggest that there is enough high school physics teachers with a major in physics/physics education to teach all physics classes if the curriculum and teacher needs are adjusted in high schools. Curriculum and advisement appears to be the main issue about why students do not get to take a physics class earlier in their high school years. In addition the number of physics classes available to students are lower than biology and mathematics classes. For example, Kansas Qualified Admissions Precollege Curriculum requires 3 approved units of Natural Sciences selected from a list of (17 total units) classes that include 6 Biology units (Biology, Advanced Biology (second year), Marine Science, Botany, Genetics, and Microbiology), but only 1 Physics unit (mandatory). It also requires 3 approved mathematics units from a list of 3 total units (Algebra I, Algebra II and Geometry). Kansas Qualified Admissions Precollege Curriculum is very much of an indicator of the high school curriculums across the state. In some schools, physics is offered as an elective and many students, not taking any physics before, preferentially choose not to take physics at all. In addition, there are also significant variations from high school to high school about what subject of physics should be covered in a high school physics class. According to Kansas Science Education Standards (2007) the following topics are considered to be standards: 1) Newton’s law of motion, 2) Conservation Laws to analyze the motion of objects, 3) Mass and Energy, 4) The first and second law of thermodynamics, 5) Fundamental forces in nature, 6) Waves, 7) Interference, reflection, and refraction, 8) Accelerated charges and electromagnetic waves, and 9) Basic Electrostatics and Circuits. Some students that were interviewed expressed that they only covered half of what is given in the standards list. Even though some of the missing topics may be covered in a physical science class, the depth it is covered may not rise to the level of the physics class standards. There were also variations from one state to another as what each state considers as “standard physics subjects” to teach. In addition, the author talked to a few prospective students and their parents as they come to seek advisement. These students and their parents expressed that their schools do not offer any physics class at all due to the small size of the school and not having a physics teacher to teach it. Many Bachelors of Science (B.S.) degrees require at least College Physics I and II to be completed by students. Not having any physics background prior, these students struggle, repeat the course or in some cases drop out of school. Sometimes the problem is just not having enough algebra background to take physics classes in the high school level. These students then try to close the gap in the college level, which puts them behind.

The high school teachers play an enormous role in the lives of students. It is very important that students learn the subject from an expert teacher. A teacher that has an inadequate training in a subject will not be comfortable teaching that subject or will do a poor job teaching it. Therefore, teachers need to be trained in their field to the highest level possible. About 30% of high school physics teachers have B.S. as their highest degree, 60% have master’s degrees and about 5% have Ph.D. as their highest degree. This statistics is very important in two aspects. One is that teachers having a higher than B.S. degree will feel more prepared to teach the subject. Often times, students do not learn the subject matter deeply until they take one higher level class of the same subject. For example, sophomore or junior students taking intermediate level electricity and magnetism class often express that they understood College Physics II or Engineering Physics II classes better after taking the intermediate level electricity and magnetism class. This may be true for other subjects as well. Therefore, in order to fully understand a subject matter and teach it, a graduate degree is preferred. Second, having a graduate degree also helps with the pay scale at high school level. A teacher with a master’s degree in physics will earn about $3000 to $4500 more yearly salary than a teacher with a B.S. degree in physics. However, the pay scale is still very low for high school teachers. According to the Bureau of Labor and Statistics, the median annual salary for high school teachers was a little over $55,000 in 2013. The number one reason why people do not choose teaching as a career is due to the low pay according to surveys. This affects the teaching quality enormously. According to high school teacher survey in 2005 [9], only 4% of all physics B.S. degree holders went directly into high school teaching after graduation. The same survey indicates that about 1,150 brand new physics teachers are hired that year. Only 270 of these new teachers have a B.S. in physics, and about 90 have a physics education degree. However, the lion portion of the new hires (about 790) have B.S. degrees in different subjects, but mostly another science or mathematics. This impacts the overall quality of the physics courses delivered by the teacher, thereby hindering any interest a student might develop for more physics classes. For example, a teacher with a major in biology who teaches biology and physics may tend, quite naturally, to promote majoring in biology more than physics. The same goes with chemistry and mathematics. This may contribute to dwindling number of undergraduate physics majors. At Pittsburg State University where the author teaches, there are 500 biology majors and fewer than 25 physics majors. This may be more wide spread in the United States than just the south east Kansas area.

In the teacher training programs at Pittsburg State University, there is strong evidence that most high school teachers that teach physics lack basic physics knowledge. Analyzing several high school curriculums in Pittsburg, KS area, it is observed that there is lack of availability of high-school-level physics courses compared to mathematics and biology. There is only one physics course at the Pittsburg high school and it is taken in the senior level or can be just elective; whereas there are plenty of biology and mathematics courses. Despite the availability of Mathematics classes, there seems to be a deficiency in mathematics background. The reason for the lack of interest in physics classes may lie in the lack of mathematics background. Students feel inadequate when they take a physics class due to the lack of Algebra, Calculus or Trigonometry. According to the National Center for Education Statistics, 96% of high school graduates had completed a biology course, 70% had completed a chemistry course and only 36% had completed a physics course [10]. It is not uncommon to encounter high school students who come to the Pittsburg State University without taking a single physics course in high school. These students spend countless hours trying to catch up in algebra, trigonometry or calculus just to pass the class. Many of them get a barely passing grade or repeat the course. High schools must find a way to better incorporate physics into their curriculum. Some students express that they hate physics because the high school physics teacher was horrible and they learned nothing. These problems need to be identified and solved by high schools very fast. In general, middle schools need to look at their curriculum and find a way to make sure every student is exposed to algebra, trigonometry in addition to science classes.

There have been students who somehow develop a taste for physics but, have major algebra or calculus deficiencies before taking introductory physics classes [11]. It is so much that they cannot follow physics classes and end up changing their major. Many physics departments across the United States should not have to sacrifice from academic rigor to keep these students in their program. If these students had proper algebra and calculus classes in high school, they would not be “lost” as physics students.

There is evidence that the administrators in middle and high schools are aware of the problems mentioned above [12]. These problems are not new. They have been around for a long time. School budget restrictions may ultimately play a part in the inability of the school districts to offer more physics classes or hire teachers with a major in physics. It is imperative to build a strong middle-school-to-college-physics educational programs that invest more in the school systems and not cut their already significantly trimmed personnel budgets. The best physics teachers need to be hired and paid adequate salaries, so that they do not need to take a second job to support their families, or worse yet, leave the scientific educational field and or switch to a different profession.

3. Qualitative Interpretations

Teachers need to inspire physics students [13, 14]. How can one instill in the students a thirst for physics knowledge and build a proper foundation for further scientific endeavor, without a proper foundation at the post elementary level? In order to foster that inspiration and increase the number of physics students at colleges and universities, teachers need to be trained in the physics field specifically.

As Albert Einstein said, imagination is more important than knowledge! One technique that can be applied is to engage student in the art of engaging and inspiring young minds. As advisor for the Pittsburg State University, Society of Physics Students (SPS) chapter, the author has been involved in acquiring grants for devices to demonstrate scientific principles to young people at the elementary level, with the college aged students acting as mentors. It's kind of like taking a bunch of young Mr. And Ms. Wizards to local science fairs. The college students love the attention and adulation they receive in demonstrating such things as holograms, magnetic levitation and solar panels to younger students, and it seems to genuinely spark their own thirst for more scientific knowledge. Several of them have even decided to go on to graduate programs in physics after graduation. Their enthusiasm for learning is partly due to these learn-by-showing-others-opportunities as SPS student demonstrators. It is not a costly program. With only a few hundred dollars, one can acquire a significant amount of hands on demonstration equipment which has dazzled and drawn the attention of inquisitive young minds. This is a small beginning, but nonetheless an important part of furthering the cause of fostering a spirit for more scientific exploration and knowledge among upcoming generation of new Einsteins and Hawkings.

4. Conclusions

Interpretation of statistical facts aforementioned indicates that majority (67%) of physics classes are being taught by teachers without a physics major. The cumulative proportion of physics teachers with a major or minor in physics or physics education is about 45%. The mere fact that 96% of high school graduates had completed a biology course, where as only 36% had completed a physics course, suggests that high schools need to evaluate their curriculum and implant changes to increase physics exposure to students. Evidence suggest that there is enough high school physics teachers with a physics/physics education major in the United States.

These teachers can easily teach more physics classes given the opportunity by school administrators. However, this in return would reduce the time these teachers would be available to teach other subjects. Thus, high schools may need to adjust their curriculum to accommodate this change. In some cases this may lead to hiring new teachers. This may not be a bad investment in the long run.

A quick look at the demographic of the physics Ph.D. recipients in the United States suggests that the number of physics PhDs earned by U.S. and foreign citizens are matched in 2004 after a steady increase since 1965[15]. Although there has been large fluctuations since 1965, there appears to be an upward trend, however, in the number of physics PhDs earned by U.S. citizens since 2005[15]. The large fluctuations in the number of physics PhDs earned by U.S. citizens may be correlated to important physics events such as Russian Sputnik satellite being launched in 1957 and the consecutive increase of interest in physics and space programs in 1960s and 70s.

In more recent years, the value of physics is evident in all the electronic devices such as smart phones, iPads etc. This may be a driving force for high school students to choose physics as career in the future. Even shows like “Big Bang Theory” and “Dr. Who” have a big impact in how young students view physics. Physics, often thought to be too difficult to comprehend, does not have to be that way if there is enough adequate training early on. Algebra, geometry and trigonometry need to be taught at a higher level in middle school so that students are ready to take a physics class in their freshmen year in high school. Although the reason for not increasing the number of physics classes or hiring teachers with a major/minor in physics to teach physics appear to be economical, statistical facts indicate that there is enough physics teachers to teach all physics classes if they are not required to teach other subjects.

It is known fact that high school students in the United States are ranked way below in science and math levels compared to other countries [16]. Ultimately it is not just the increase in the number of physics teachers with a physics/physics education degree will solve all the problems. There needs to be increase in the quality of physics teachers as well. That is where the major field tests and teacher certifications should come in. The B.S. physics degrees in the United States do not offer the pedagogical training necessary to become a high school teacher. Students need to take the pedagogy classes concurrently with their major field classes or after graduation to satisfy the high school teaching requirements. Keeping in mind that there are more high school teachers with a B.S. in physics than physics education, the pedagogical training for the teachers with a B.S. degree in physics becomes even more important. Teacher certifications are very integral part of high schools as well. Perhaps more rigorous major field tests or re-training may be necessary to improve the quality of teaching.

Finally, one cannot ignore the importance of the high school teacher salaries in the United States. It is absolutely imperative to make the salaries attractive enough so that these teachers will remain in the profession. If the Unites States government wants to insure the future scientific competitiveness of America, it must find a way to improve and invest in its physics education system.

References

[1] Paula Heron and David Meltzer, “The Future of Physics Education Research: Intellectual Challenges and Practical Concerns,” Am. J. Phys. 73 (5), 390-394 (2005)

[2] David Hammer, “Student Resources for Learning Introductory Physics,” Am. J. Phys. 68 (S1), S52-S59 (2000)

[3] Jonathan Tuminaro and Edward F. Redish, “Elements of a Cognitive Model of Physics Problem Solving: Epistemic Games,” Phys. Rev. ST PER 3 (2007)

[4] Young-Jin Lee, David J. Palazzo, Rasil Warnakulasooriya, and David E. Pritchard, “Measuring Student Learning with Item Response Theory,” Phys. Rev. ST PER4 (1), 010102 (2008); Lei Bao and Edward F. Redish, “Model Analysis: Representing and Assessing the Dynamics of Student Learning,” Phys. Rev. ST PER 2 (010103), 16 (2006)

[5] Rosemary Russ, Rachel Scherr, David Hammer, and Jamie Mikeska, “Recognizing Mechanistic Reasoning in Student Scientific Inquiry: A Framework for Discourse Analysis Developed from Philosophy of Science,” Sci. Ed. 92, 499-525 (2008)

[6] Chandralekha Singh, “Assessing Student Expertise in Introductory Physics with Isomorphic Problems. I. Performance on Nonintuitive Problem Pair from Introductory Physics,” Phys. Rev. ST PER 4 (1), 010104 (2008)

[7] American Institute of Physics, focus on, December 2014 issue, https://www.aip.org/sites/default/files/statistics/highschool/hs-whoteaches-13.pdf

[8] Jason G. Hill and Kerry J. Gruber, Education and Certification Qualifications of Departmentalized Public High School-Level Teachers of Core Subjects: Evidence from the 2007-08 Schools and Staffing Survey, Statistical Analysis Report [NCES 2011-317] (National Center For Education Statistics, U.S. Department of Education, Washington, D.C., 2011). Available at: http://nces.ed.gov/pubs2011/2011317.pdf

[9] http://www.phystec.org/phystec/webdocs/status/aip_careerpaths.pdf

[10] National Center for Education Statistics, http://nces.ed.gov/fastfacts/display.asp?id=97

[11] http://web.calstatela.edu/faculty/sfelsze/CSULA_Calculus_Reform.pdf

[12] Private communications with high school teachers and administrators

[13] The New York Times, “When Science Suddenly Mattered, in Space and in Class”, Cornelia Dean, 2007, http://www.nytimes.com/2007/09/25/science/space/25educ.html?pagewanted=all&_r=0

[14] Nova, “Sputnik’s Impact on America”, Paul Dickson, 2007 http://www.pbs.org/wgbh/nova/space/sputnik-impact-on-america.html

[15] http://www.aps.org/programs/education/statistics/citizenship.cfm

[16] National Public Radio (NPR), "U.S. Students Slide In Global Ranking On Math, Reading, Science", Bill Chappell, 2013, http://www.npr.org/sections/thetwo-way/2013/12/03/248329823/u-s-high-school-students-slide-in-math-reading-science