Getting From Facts to Policy: An Education Policy Convening
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Submitted by:
The California Science Education Initiative

Policy Recommendation on School Governance:

Improving student outcomes in science classrooms through definition of minimum required levels of instructional equipment and materials.

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Problem Statement: While all subjects benefit from hands on activities, science is unique in the core academic subject areas in the extent to which it involves doing hands-on labs and projects involving specialized tools and equipment. A significant body of research has shown that regular hands-on activities in science which are linked to the academic course work are a necessary part of successful science programs[1]. Science laboratory activities stimulate student interest in the field and provide vital skills for future success in our increasingly technology based work environment. Thus any definition of instructional materials for science classrooms which fails to address minimum levels of equipment/materials is incomplete. Group size has been shown to be an important factor in student laboratory achievement and must be addressed in defining minimum acceptable levels of supply[2]. Class sizes are a major factor in safety and achievement with the NSTA recommending maximum class sizes of 24 for laboratory science.

Despite the Williams Settlement[3] significant equity issues remain in California's science classrooms. In the settlement no minimum level of laboratory experience, equipment or materials is established. While every student has been guaranteed a textbook for at home use, there is no guarantee that they will work with modern science equipment or in fact any laboratory equipment at all. It is left to the individual school district to provide certification that there are sufficient instructional materials to teach laboratory science. The state has not provided guidance as to what equipment or materials should be used to provide the hands-on learning experiences that have been shown to be a vital part of science education. Thus a district can "certify" that they are providing sufficient science instructional materials when in fact their students are provided with a clearly inferior science education. Students receiving an inferior science education are less likely to believe they can succeed in rigorous science and engineering programs that lead to high paying careers.

Policy Issues and Recommendations: Is lack of science materials a real problem? Consider two public high schools within 15 miles of our state capital. These schools are emblematic of the stark differences which led to the original decision in the Williams case. Data from the case indicated up to 49% of public school science teachers reported having inadequate equipment and materials to teach standards-based classes[4].

The first school is less than 10 years old. At this school in a suburban area students work in state-of –the-art science classrooms. Students perform labs using modern equipment of the same type as is used in industry and university labs. Students have sufficient materials and equipment that they work in groups of two. Labs are performed on a weekly basis and tied directly to the state framework for the topic areas. The science department budget at this school is more than $10/student/year.

The second school is on a campus 40 years old. Due to student population growth and shifts in program emphasis, many science students attend classrooms used in the past for home economics or standard academic classes. These classrooms lack lab benches, sinks and other materials normally found in science classrooms. The science equipment that does exist in these classrooms is of various ages and in poor condition. Students often must perform "paper" labs (due to equipment/material shortages) that posit a set of conditions and ask them to predict the outcome of an experiment they are unable to perform. When the students are able to do actual labs they are forced to work in groups of 4-6. This school had a science department budget of $0/student last year.

Students at the first school are being introduced to science as it is practiced both in industry and at college. Students from this school are likely to find science interesting and enter university science and engineering programs fully prepared to be successful. Students graduating from the second school have received a substandard education in science. The second group of students is less likely to be prepared for, or even elect to enter a program in science or engineering at the university level.

Under the Williams settlement both school boards have certified that "students in science classes have laboratory equipment available"[5]. Clearly there are flaws in our system if these two circumstances are considered equal. In reviewing the California Department of Education and State Board of Education definitions of instructional materials it becomes clear that there is no guidance provided on how to offer labs or what equipment/materials should be available to the students. The Williams review forms provided to county offices by CDE to use in the classroom review carry the statement, "…science laboratory equipment is made available to all students enrolled in these 9-12 science courses."[6]. On the basis of the wording in the CDE-suggested board certification and the Instructional Materials Survey document, a single microscope in a classroom would be grounds for acceptable compliance results!

Beyond providing some minimal level of materials there is a profound need to train teachers of science on the incorporation of hands-on activities into the classroom. Numerous researchers have performed studies on the role of teacher preparation on student achievement in science which support the need to provide meaningful training specifically addressing laboratory activities[7]. Studies have shown that the least experienced teachers are most likely to be located

at those schools with student performance deficits[8]. There is a need to link the application of resources for equipment/materials to the training in how to use the tools in boosting student achievement. Further, the lack of experience in teaching hands-on science speaks directly to the need to provide guidance on equipment/materials needed and their use.

Policy Proposals

1) Create minimum acceptable instructional equipment/materials lists. These recommendations should be based on the experience of California's science classroom teachers and must be subject specific. An independent professional organization such as the CSTA might be well positioned to put study teams of science teachers together to accomplish this. Any recommendation should provide for the use of modern technologies and meet best practices guidelines from science education organizations[10].

2) Survey all science classrooms in the state to establish compliance with minimum levels established for the teaching of hands-on science. The survey instrument must be detailed enough to quantify the type and number of student-use items. A good model for this survey would be the CTAP instrument which most teachers in California answer on a yearly basis[11].

3) Provide meaningful professional development to science teachers[9]. Many science teachers have never been given the opportunity to incorporate modern hands-on science activities. These teachers must be assisted in their transition into the modern, well equipped science classroom. Any training offered should be subject specific, teaching physics labs is very different from biology and the methods and skills needed cannot be taught in a general one size fits all session.

A Start in Addressing Larger Issues

In "Rising Above, The Gathering Storm" an eminent group of business, education and governmental leaders discussed the crisis in talent the US faces in science and engineering. The US graduates fewer engineers today than in 1985. Fewer entering freshman choose engineering and of those that do, there is a higher attrition rate than in the past[12]. There is substantial evidence that improved science education at the K-12 years leads more entering college freshmen to chose science and engineering majors and improves their overall performance[13].

The policy recommendations made above are a small first step in improving California's science education system. While these steps are linked to an understanding that the Williams case decision has to include equity in science equipment/materials they are by no means the only changes needed to improve science outcomes in California. In the longer term improved science education in California will help to address societal equity issues and labor and workforce issues.

Science an Undervalued Subject

From the house you live in with running pure water, air conditioning, healthy foods, heating and electricity to the roads you drive, to the entertainment you chose, almost all aspects of your life are improved or made possible by science and engineering. It is interesting then that science is such an undervalued topic in our K-12 school system.

K-6 Science (Missing in the API)

In our K-6 system, science is only tested in the 5th grade. As such it comprises between 3 and 5% of an elementary schools API[14]. Given this fact it is not surprising that science has virtually disappeared from many elementary school classrooms. What isn't tested is undervalued in our system where success is defined as a higher API.

One recent study indicates that many children form their impressions about science and a belief that they don't like it, during these early years when it is increasingly relegated to second class status, taught from a book or ignored[15]. Many children learn to read because they want to learn about dinosaurs or bats or rockets and the minimization of science in the early years removes interesting subjects from our student's lives. Science is an exciting subject (when powerfully taught) that integrates math and literacy in the context of their use.

Many elementary teachers feel under-prepared to teach science. In an environment where reading/language arts and mathematics take precedence science is easily pushed aside. Elementary teachers deserve the consideration on professional development in the teaching of science. The addition of science specialists on elementary campuses would also help to jump start powerful science teaching in the early grades.

7-12 Science (Under Developed, Under Funded)

In grades 7-12 science teachers are routinely given professional development on teaching reading or writing across the curriculum. In order to become better at teaching science these teachers should be working with their subject matter peers exploring powerful methods of teaching hands-on science. Professional development for a science teacher should be about science.

In these same 7-12 classrooms there is often insufficient funding. Science powerfully taught is more expensive than a standard academic subject. Modern science incorporates electronic sensing elements, data-logging and computer analysis on top of the beakers, chemicals, pendulums and frogs that were typical 25 years ago. While the science standards speak to the need to incorporate modern technology into the curriculum there are seldom sufficient funds to do so. Science is expensive to teach but creates the wealth of our society and is worth the investment.

Science Key to Tomorrow

Science is increasingly the standard by which we will be measured as a society. Between climate change and global competition California can only hope to remain a leader if we are successful in creating a population of scientifically literate and upwardly mobile people. We must innovate, invent and create our way into future prosperity. These are the processes carried out by scientists and engineers who are, only sometimes, being nurtured in K-12 science classrooms today.

References

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