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Paper Title: **MISCONCEPTIONS ABOUT SCIENCE EDUCATION REFORM**
Author: Speece, Susan P.

Abstract: Change is not an easy concept to be accepted. If change involves someone else's lives, then we usually are willing to accept change, but when it affects our own lives directly, we tend to get just a little uncomfortable. Change in the way science is taught is no exception to this conflict. For the past century there have been multiple efforts to look at how science is taught and to improve the methods of instruction, to come up with the perfect formula, as it were, to teaching science. Unfortunately, we do not have clones teaching science, nor do we have clones learning science and therefore we are hard pressed to develop one perfect way to teach science. Perhaps the most notable science education reform in recent history is that which took place immediately after the Russian Sputnik was launched and the U.S. realized that their mortal enemy was more advanced in science and space technology. The changes that took place in science education during the 1960's did encourage more children to consider careers in science. As good as some of the programs were that came out of the 60's for students interested in sciences, the programs seemed to widen the gap between those interested in science and those who had no interest in science. Application to everyday life was missing. We had succeeded in producing more scientists, but we failed to impart an understanding of the importance of science in every person's life.

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MISCONCEPTIONS ABOUT SCIENCE EDUCATION REFORM

Dr. Susan P. Speece, Anderson University, USA

INTRODUCTION

Change is not an easy concept to be accepted. If change involves someone else's lives, then we usually are willing to accept change, but when it affects our own lives directly, we tend to get just a little uncomfortable. Change in the way science is taught is no exception to this conflict. For the past century there have been multiple efforts to look at how science is taught and to improve the methods of instruction, to come up with the perfect formula, as it were, to teaching science. Unfortunately, we do not have clones teaching science, nor do we have clones learning science and therefore we are hard pressed to develop one perfect way to teach science. Perhaps the most notable science education reform in recent history is that which took place immediately after the Russian Sputnik was launched and the U.S. realized that their mortal enemy was more advanced in science and space technology. The changes that took place in science education during the 1960's did encourage more children to consider careers in science. As good as some of the programs were that came out of the 60's for students interested in sciences, the programs seemed to widen the gap between those interested in science and those who had no interest in science. Application to everyday life was missing. We had succeeded in producing more scientists, but we failed to impart an understanding of the importance of science in every person's life.

Each time we have approached the problem of teaching science more effectively for the times we have fallen short of the ideal goal. As a result, there is a pessimism about the potential success that any educational reform, and particularly science education reform might have. In spite of the inadequate results of the past, in the mid 1980's scientists and science educators began to revisit the need for science education reform. Poor performances on the part of U.S. students on internationally compared exams along with employers' frustrations with the technological illiteracy of new employees fueled the need to revisit science education reform. While we could debate the weaknesses of some of the comparisons that have been made from the international exams, students in this country are not doing as well as we would like them to do when it comes to scientific literacy. This means that our future leaders will also come from the ranks of those who have been identified as being scientifically illiterate. "Scientific literacy - which embraces science, mathematics and technology - has emerged as a

central goal of education. Yet the fact is that general scientific literacy eludes us in the United States." (AAAS 1989).

In 1990 the President and the National Governors Association developed national educational goals. Eventually these goals gave rise to the National Council on Education Standards and Testing. In the past year several disciplines have begun developing national standards for curricula. Reform in the sciences, however, preceded the President's and national Governors' efforts. Early in the 1980's groups such as the National Academies of Science and Engineering, National Science Board, American Association for the Advancement of Science (AAAS), National Academy of Science (NRC), National Science Teachers Association (NSTA) and others each began looking at the critical need for improving the quality of science knowledge amongst our citizens. Technology has advanced at incredible rates, yet society's understanding of the technology, let alone the science behind the technology, is seriously lacking. If there is any hope of society making sound scientifically based decisions, then the way science is learned and applied by the general public must be altered as well. (Speece, 1993)

There are four primary reform movements that will impact directly on science education: National Research Council's *National Science Education Standards*, AAAS's *Project 2061,* National Science Teachers Association's *Scope, Sequence and Coordination* , and The National Board for Professional Teaching Standards.

NATIONAL SCIENCE EDUCATION STANDARDS

The science reform efforts of the early 80's lacked a sound foundation, a cohesiveness to pull them together and provide an opportunity for succeeding. Finally, in 1991, the NRC at the urging of NSTA, AAAS, the Department of Education and the NAS formed a National Committee on Science Education Standards and Assessment (NCSESA) to establish National Science Education Standards that can serve as a foundation for curricular reform.

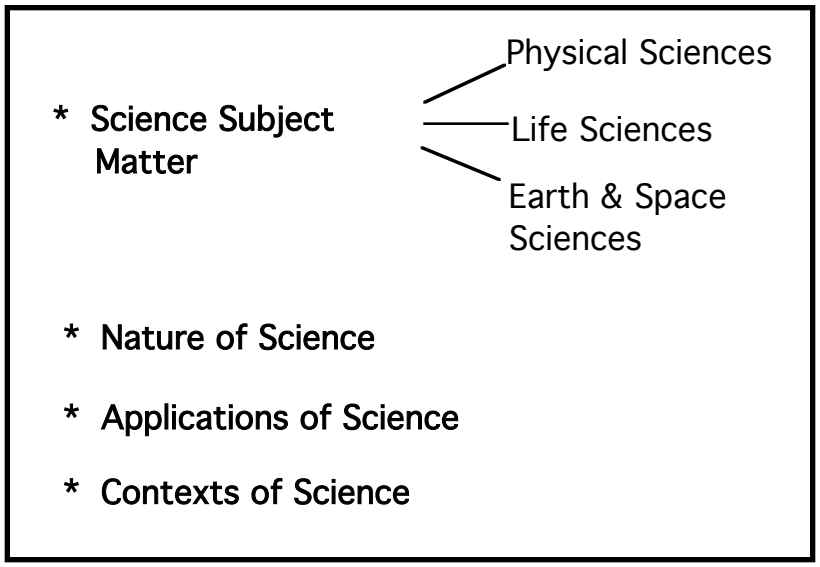
The beauty of the National Science Education Standards is that it not only sets standards for curriculum development, but it also mandates and sets standards for assessment and teacher preparation and performance. In other words, colleges and universities will have to insure that science teachers are being adequately prepared and teachers and school systems will have to develop meaningful tools by which to determine if the students are learning what **local goals** claim they should learn.

Notice the words local goals were stressed. The National Standards are not intended to tell the teacher what they must teach. To quote from the Preface of the February, 1993 Sampler:

> "It is important to understand something about what is meant, and what is not meant by "standards" in this context -- what the concept is, as applied to any of several major disciplinary areas:
>
> > National standards for curricula should be goals for young people in different age brackets to strive for -- demanding but attainable learning goals providing a vision of what we want all of our young people to know and be able to do.
> >
> > They must not be reducible to a set of minimum competency thresholds.
> >
> > The standards should help states, localities, teachers and others who select or develop curricula or frameworks -- allowing for local variation and adaptations, but providing sufficient consistency from school, town to town, and state to state that a change of schools or household move does not create educational chaos for the student.
> >
> > They must not be federally mandated; their use by teachers, schools, districts, or states should be voluntary.
> >
> > The standards should be openly accessible and presented narrative form with illustrative examples, so as to be readable by those whom they affect and those who will effect their use: students, teachers, administrators, parents, school board members, legislators, etc.
> >
> > They must not be pronouncements from on high, but should emanate from the teaching profession with strong involvement of disciplinary experts, educators, and key constituencies.
> >
> > It is important to develop professional standards for teaching as well as assessment standards, both aligned with the valued learning defined in the curriculum standards -- the goal being to have three interrelated sets of standards, covering curriculum, teaching, and assessment, all backed by nationwide consensus support." (NRC, 1993)

The February "Sampler" provides an outstanding introduction and background for the need for National Standards. The framework for curricular/content standards is presented with specific samples from both the physical and life sciences. The standards for teaching and assessment are not expected until later in 1993.

The curricular framework proposed for the final draft identifies what all students should know within four general categories:



Generally speaking, the design is good. There are some particulars to be worked-out but overall the curricular standards make sense and are a good foundation for the development of local curriculum. Of critical importance is the fact that throughout the entire document, the concept of teaching science as science is done is stressed as well as stressing the application of science to our lives.

Considerable work still remains to be done on the assessment standards and the teaching standards. If politics do not interfere, however, I expect equal quality coming out of the other two working groups.

PROJECT 2061

In 1989 AAAS published their document *Project 2061*: *Science for all Americans.* in which they detailed a long term revamping of science education. The project involved many scientists and science educators in the beginning. As the project progressed more classroom

teachers were brought into the development process. Early in the year (1993) they published their *Benchmarks for Science Literacy*, a draft document that provided curricular focus to the *Project 2061*. *Benchmarks* was intended to provide a coordinated set of reform tools for educators to use in their efforts to help students achieve literacy in science, mathematics, and technology, as outlined in *Science for All Americans*.(AAAS, 1993) *Benchmarks*. has undergone considerable review by teachers, science educators and the scientific community. Since May AAAS has been processing all of the input offered with an attempt to edit the document, coordinate it with the guidelines being published by NRC, and come up with another draft.

While *Benchmarks* is not a perfect document there are some considerable strengths. It offers many alternative activities for each grade level, it encourages students to see more than one application of science to their life experiences, it encourages students to spend more time in science classes and it stresses an interdisciplinary approach to science.

On the negative side, the document seems to be ponderous and the design may be difficult for teachers to accomplish. Some reviewers felt that there was too much emphasis on the classical science or science history and not enough on the current scientific development. This is always a difficult balance to maintain. Perhaps the greatest area of contention is the fact that considerable time is spent on the social sciences. While the social sciences place the "hard" sciences in context for the general learner, there may be a limit to the quantity and usefulness of the social sciences.

SCOPE, SEQUENCE, AND COORDINATION

1989 was an active year for science education reform. It was also in that year that National Science Teachers Association published an article entitled "Essential Changes in Secondary School Science: Scope, Sequence and Coordination"(SSC). The article proposed a pattern for science education reform that called for the teaching of all of the sciences in each year from middle school through high school. The integration of scientific principles was an essential component of the concept. The elimination of the age old "layer cake" pattern of teaching science, i.e., life sciences followed by chemistry and then physics, was really at the heart of the article.

Since SSC was published, large sums of NSF funds have been designated to support six centers where the ideas expressed in the article can be implemented. At the same time many teachers have expressed considerable anxiety as to whether or not the implementation of SSC meant that they would not have a job in another five to ten years. In fact *Project 2061* raised some of the same concerns. Should the teachers be concerned? Part of the answer might be found

in a quote from Paul DeHart Hurd who stated "Biology, chemistry, physics, geology have been fractioned into 40,000 research fields represented by more than 70,000 journals, 29,000 of which are new since 1978. No scientist today would claim to know the whole of a discipline." (Hurd, 1990) If a practicing scientist cannot know the whole of his/her discipline, do we really expect a chemistry teacher or a biology teacher to know the whole of all sciences? While this may be an administrators dream, it is clearly the educator's nightmare and unrealistic. Most likely, science teachers will not have to fear that they will no longer have a job.

Scientists usually are trained in a fairly narrow field of interest. If they intend to conduct meaningful research, however, they often have to learn something about other fields of science. For example, a researcher might be trained as a plant biologist, but may wish to look at the nature of Ca^{+2} channels as they effect cell-to-cell communication. It is not enough for the plant biologist to know only about plants and how and where they grow, they must also know something about cell biology, chemistry, the mathematics of proportions and a little about physics. So it should be with classroom science teachers and reform. Science research is not conducted as a solo venture, in an intellectual vacuum. Likewise, the interdisciplinary presentation of school science should not be a solo venture conducted in an intellectual vacuum.

Each of the six centers following NSTA's concepts have been free to interpret the document into program. Some are using a collegial approach while others are trying some new combinations. It will be interesting to see how each deals with this concept of interdisciplinary science and what level of success is achieved by the learners.

NATIONAL BOARD FOR PROFESSIONAL TEACHING STANDARDS

This is the least obvious entry into the science education reform formula. "The National Board for Professional Teaching Standards (NBPTS) is an independent, nonprofit organization. The mission of the National Board for Professional Teaching Standards is to establish high and rigorous standards for what accomplished teachers should know and be able to do, to develop and operate a national voluntary system to assess and certify teachers who meet these standards, and to advance related education reforms for the purpose of improving student learning in American schools...National Board Certification (NBC) is designed to complement, not replace, existing state licensure procedures for novice teachers." (NBPTS, 1993)

NBPTS has been funded to the tune of $45 million over the past six years. Most of those funds have come from industry and foundation grants. Ely Lily Foundation was one of the initial funders in 1987. Individuals serving on the governing board represent the teachers'

unions, industry, teacher preparation institutions and some of the professional teaching organizations.

The power this group seems to have is impressive. They also are in the process of developing science teacher certification standards. While the draft for the science teacher certification standards were not made available at the June National Forum, there were assurances that the NRC document would provide much of the influence for how the certification standards would be developed. This could provide a vehicle by which the National Science Teaching Standards accomplish their teaching standards, thus bringing the science education reform full circle.

MISCONCEPTIONS

In the past, successful science education reform has been considered an oxymoron, it just could not happen. Those doubts still plague the current reform efforts. It is my perception, however, that this time the pessimists may be wrong. The factors that point toward the potential success of the current reform movements are:

A. The acknowledgment that teachers must be an integral part of the reform, from start to finish.

B. The acknowledgment that any successful reform movement must be founded on sound thinking that clearly identifies where we want to go.

C. The acknowledgment that a successful reform movement cannot just look at curriculum, rather it must also provide for assessment and the changing of how teachers teach and how they are prepared to teach.

D. The coordination of all efforts, a pooling of resources and information for the purpose, not of advancing one group over another, but of providing the best science education for **all** students.

It is my contention that the science education reform movements of the 1990's have the potential of meeting all of the above conditions. For that reason I am hopeful that by the turn of the century we will see a successful program in which all of the students in the United States will have a reasonable level of science literacy.

CONCLUSION

For perhaps the first time in the history of all science education reform movements, we have an opportunity to implement changes that will make a real difference for the way **all** children learn science. Never before have reformists combined curriculum development with teacher preparation and assessment, and yet it is critical to the long term success of any educational program to have a means to adequately prepare teachers and to assess what is going on in the classrooms. Large numbers of classroom teachers have been involved in all of the projects and it shows in the quality of materials being developed at each level.

As the full set of NRC standards and accompanying activities are made available many avenues of publication are being employed to get the information to the teachers and to the school administrators. All of the projects discussed here have received extensive funding, both from the private and public sectors. In most cases field testing is being implemented to determine if the concepts will work in the real world of students. The final factor that seems to indicate that this time we may just have science education reform right is the fact that the various groups are talking to one another. I have mentioned the four major reform movements, there are others, but the communication between groups is impressive. The tendency toward territorialism has been suppressed for the greater good of the students and the future of the nation.

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