A CONCORDANCE OF SCIENCE EDUCATION THEMES IN THE SDAS *PROCEEDINGS*: THE FIRST HUNDRED YEARS

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ABSTRACT

Several common science education themes are apparent in the articles and addresses contained in the last 100 years of the *Proceedings of the South Dakota Academy of Science*. These themes run parallel to issues and challenges arising in South Dakota at the time. Selected from the many themes found in the *Proceedings*, those examined here include papers whose emphasis is on 1) the need for science education of the public, 2) specific effective science teaching methods, and 3) certain philosophies of teaching and learning based on existing contextual factors. In the final section of this paper, some unresolved issues and challenges are addressed. Additionally, some thoughts on plausible solutions are explored.

INTRODUCTION

From the very beginning, the *Proceedings of the South Dakota Academy of Science* reflected considered opinions about not only the structure of teaching science, but also the attendant methods and the impact on student learning resulting from various approaches. Insightful and powerful teaching practices were described in at least 24 of the articles. The first example is an abstract in the first issue (1916p85) of the *Proceedings*: "The Relationship between Equipment and Efficient Science Teaching," by A. B. Carr.

The science education themes gleaned from the abstracts, articles and Presidential Addresses are certainly as relevant today as they were 100 years ago. It seems incredulous that society's trappings and technologies have so radically changed, but that the important issues and concerns surrounding the science education of each generation's students and the best methods of teaching have scarcely been altered. The insights of teachers and professors in the last century have barely evolved – how can that be?

Not only do similar ideas and challenges recur throughout the *Proceedings*, but also many of the proposed solutions are similar, if not the same. Some commentary is added here to suggest reasons for many of our continued educational dilemmas, despite concerted efforts of decades of well-educated and dedicated teachers at all levels leading up to today.

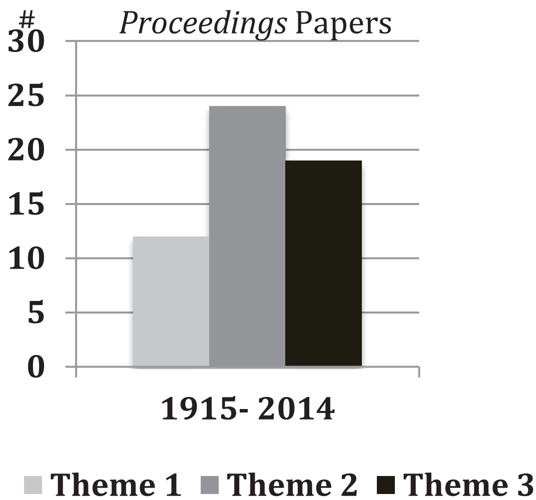

Figure 1. Themes addressed in Proceedings papers. Theme 1: the need for science education; Theme 2: science teaching methods; Theme 3: philosophy of teaching and learning.

The frequency of the articles supporting the three themes selected from the *Proceedings* for this paper are shown in Figure 1 and include: 1) examples of articles with an emphasis on the need for science education of the public, 2) illustrations and recommendations of specific and proven science teaching methods, and 3) promotion of certain philosophies of teaching and learning based on specific contextual factors at the college and secondary levels.

There were so many excellent papers and ideas that appeared throughout the *Proceedings* which made it very difficult to select the few that I highlight here. I ask the reader (who may have authored a paper not selected) to not take offense if his or hers is not among them.

SCIENCE EDUCATION OF THE PUBLIC

More than twelve articles in the *Proceedings* dealt with the topic of science education of the public in a major way, with many more mentioning the challenges in getting the public to accept scientific points of view and to delve into the heart of a science issue instead of buying into surficial or politically expedient positions on science and science education issues.

L. K. Akeley from the Department of Geology at the University of South Dakota, in his SDAS Presidential Address (1921p65) decried the "futility of enlisting" on the part of the general public any "intelligent appreciation of scientific research." Akeley further maintains "the restricted and educated public that ought to be an intelligent supporter…can be swept off its feet by newspaper propaganda." This argument sounds no different than today's mostly scientifically bereft political climate. Speaking to the attempt to "popularize Einstein's theories, as he visited the US, in 1919, Akeley pronounced:

> *The recent efforts made by the magazines and newspapers in the direction of popularizing science have shown the utter futility of ever enlisting any intelligent appreciation of scientific research on the part of the general public. (Akeley 1921)*

In his SDAS Presidential Address, Sven G. Froiland (1964p36), from the Department of Biology at Augustana College posited:

> *Not everyone, by any means, really understands what science and technology represent. As a matter of fact, not everyone really understands the difference between a scientist and a technician...the relationship of the general public to the scientific world, the responsibility of the scientist and the lack of communication between the humanist and the scientist and even the morality of the scientist!! (Froiland 1964)*

Dr. Froiland goes on to discuss that “gross misunderstandings” by the public about science and scientific work are not surprising as most of the public has little formal science background to bring to bear on these issues. Hence, much misrepresentation of scientific conclusions, suspicion and distrust of science and scientists on the part of the public can (and does) occur.

This process seems to have accelerated during the 2000’s as the public remains suspicious that global warming is some sort of hoax. This is the result of sustained resistance by certain political candidates to remedies that might affect businesses directly impacted by enhanced environmental protection measures. Legislation in many states has been written to refute that the global warming effects on our planet are caused by human endeavor. The South Dakota Science Standards committees in writing new standards in 2012-2014 were charged by the state legislature NOT to attribute any environmental impact as due to human activity in any of the wording in these standards.

In his SDAS Presidential Address (2005p13), Robert Tatina of Dakota Wesleyan University biology department, reiterated and further highlighted the issue of scientific literacy among the general population. Citing data from the National Science Foundation and the National Science Board, he delineated the ways in which a “general lack of understanding about how science works” proliferates in American society. He offers several reasons for this problem – including textbooks that lack depth and do not incorporate clear explanations of basic science principles, the structure of our school systems and the lack of funding and science required in the general curriculum both pre-college and in teacher preparation programs – especially among the elementary pre-service teachers.

> *There is a pervasive acceptance of pseudoscience. From the Science & Engineering Indicators 2004, about 50% of the US population believes in ESP, about 40% believe that astrology to be at least somewhat scientific, and about 30% believe in lucky numbers (National Science Board, 2004). (Tatina 2005)*

Gary Larson, professor of biology at South Dakota State University, in his SDAS Presidential Address (2012p17) addressed the issue that our legislators and governors often do not understand the needs of science in South Dakota. He maintains that the SD K-12 educational system is "jeopardized" by inadequate state financial support and listed several causes for this precarious situation, among them: "reforms" suggested by Governor Daugaard which amounted to additional cutting of the already emaciated state education budget. This trimming was supposedly justified by "low test scores" and higher per pupil funding as compared to 1971 (with no adjustments for inflation). Not addressed was the abysmal teacher pay—49th (in 2012) among all states. It is now 50th and several thousand dollars lower than all of our surrounding states.

A one-time teacher bonus was suggested by the governor as a solution to the problem of accelerating teacher shortages. Because twenty percent of the state's share of the money is passed through from the federal government, South Dakota spends, on average, $1600 less than what has been determined to be the lowest sustainable per pupil funding.

> *First, South Dakota cannot hide a poor environment for teachers. The state's record of education funding and how teachers are treated in South Dakota is online for all to discover and…unless and until teachers and school administrators are valued as professionals, we will lose top educators to other states. South Dakota must compete for good educators rather than penalize the good ones it has. (Larson 2012)*

Dr. Larson also cites the state legislature's adding of layers of "accountability" measures to our overburdened and ill-supported schools. He urges an overhaul of the financial underpinnings of funding for education and that citizen's urge politicians to finally increase the SD state-based share of funding for our public schools.

SUGGESTED METHODS OF EFFECTIVE SCIENCE TEACHING

At least 24 *Proceedings* articles addressed specific teaching practice and include methods with a discussion of factors in practice that impede deep and sustained science learning. Several representative examples are highlighted here.

In his paper, J. G. Hutton (1929p53) espoused the responsibility of the scientist to become an effective teacher, "…to shape the philosophy of college students" so that it encompasses a more scientific perspective. Dr. Hutton encourages the science instructor to bridge the gap between what the student already knows with the theories of science presented – so as not to "lose" the student and "reduce the intensity of the growing pains." He saw this important function of the scientist as a "moral duty."

> *It is possible so to present the facts of science that the student will be so jarred and shocked and confused that he experiences great anguish of soul and may even develop a radical and unsocial philosophy. Facts and theories should be presented according to the ability of the student to assimilate them without disaster to himself. Hutton (1929)*

In his Presidential Address (1939p11) Ward L. Miller, from the botany department of South Dakota State College, examined "Teaching Techniques in the Light of New Demands Made Upon Science." In his address, he asked many questions, including: "how can the teaching of science to an ever increasing number of students be continued when there is no corresponding increase in room or equipment?" He suggested that students were entering college for reasons different than those in the past and he lamented that many were not serious students and had "varying capacities." He maintained that the solution to the enlarging student body was substituting the "lecture-demonstration method" of teaching for the laboratory method.

Dr. Miller lamented that "making every student learn the same way" was at the heart of the problem and neglected those who would become scientists as well as those who needed a more "hands-on" approach to really develop a scientific way of thinking and to acquire skilled laboratory techniques. His plea for students to "understand" over "memorizing facts" also speaks to the educational environment today, especially in public schools where "teaching to the test" has fundamentally changed the way the sciences (and other subjects) are taught. Dr. Miller reiterates his aims:

> *But, I believe understanding to be the important aim for the great majority of beginning students; and I can teach understanding better with the demonstration method than I can with the individual laboratory method…All are better satisfied. (Miller 1939)*

In the *Proceedings* (1957p151), Kenneth V. Olson, from Northern State Teachers College in Aberdeen, presented findings from his unique controlled mixed methods study "An Experimental Evaluation of a Student-Centered Method and a Teacher-Centered Method of Biological Science Instruction for General Education of College Students (p181)." He outlined and defined four "pivotal" objectives of science teaching as the following:

1. Acquisition of factual information in science.
2. Understanding and application of the principles of science.
3. Understanding and application of the elements of the scientific method together with its associated attitudes, and
4. Skill in the basic tools peculiar to a specific science.

Dr. Olson centered his research questions on two conflicting methodologies as evidenced in the title of his paper. He found that even though students in both methods increased in knowledge of subject matter and scientific thinking ability, students in the teacher-centered group performed better on subject matter questions than those in the student-centered group. Nonetheless, there were no differences between methods in student performance on "some inductive aspects of scientific thinking."

His findings, however, yielded some surprising results. Looking at the mean initial and final scores on student performance and comparing boys and girls, he found that girls performed significantly higher than boys in both methods on their "ability to recall and apply biological facts and principles." Boys, on the other hand, performed significantly higher in the teacher-centered method than in the student-centered method on this ability. I might add that students were far more familiar with the teacher-centered method so that there may have been a learning effect at play here with the student-centered method. More scientists might well reserve drawing conclusions from experience and instead apply their science backgrounds to the determination of teaching method success through controlled studies such as this one. Such experimental methods are commonly used in science education studies today.

In his Presidential Address (1987p15), Marvin Seines, a high school physics teacher, gives an object lesson as he illustrates the qualities of excellent high school science teaching and maintains, " The textbook alone is not science or the curriculum." He makes the case that science learning does not end with graduation, but that it must be a process of "life-long learning." Defining science as both a "body of knowledge and a process of investigation," Mr. Seines describes the teacher as the "catalyst in the educational process." But, he pleads

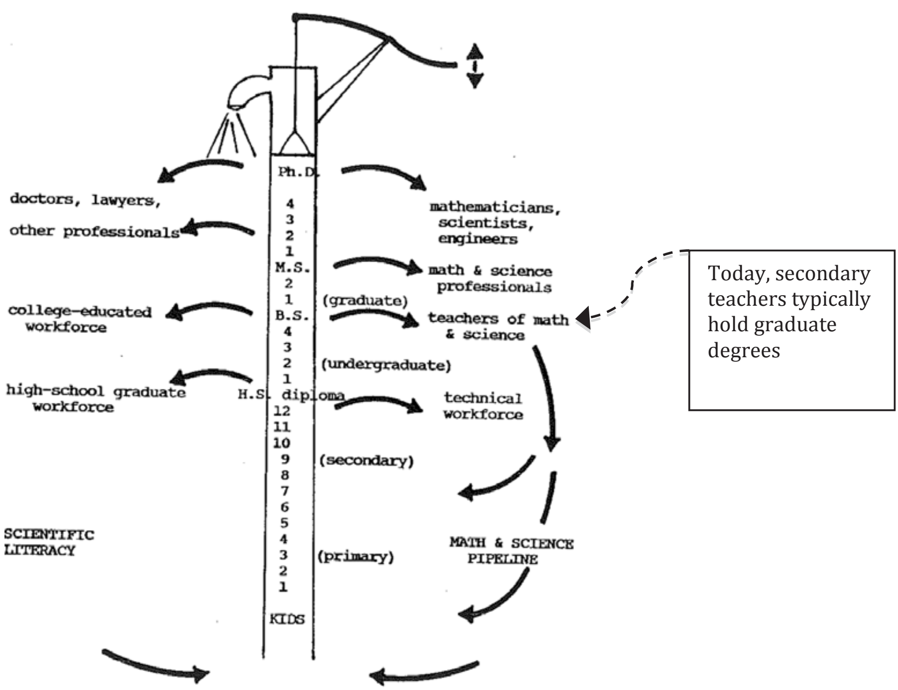

Figure 2. The math and science pipeline, or pump.

for support (also seen in the tight budgets of today) not only financial, but also in awareness by legislators and other state officials that there is inherent danger in ignoring math and science education. Demanding improvement doesn't support, but hinders the teacher, where there is not also a coherent plan with clearly elucidated solutions.

SDAS President Lynn Hodgson, of the Department of Mathematics and Natural Sciences at Northern State University, in her Presidential Address (1992p17), "Priming the Pump," (p18) describes a math and science "pipeline" to produce more scientists and science teachers. Her goal is science literacy for all students with a continuous pipeline of well-educated students who then pursue math and science careers. Her pipeline is illustrated in Figure 2.

All students enter school (at the bottom of the pump), become (hopefully) scientifically literate in the primary and secondary grades. Then, after high school, differentiate in their choices of profession or enter higher education. Today, math and science teachers, especially in secondary schools, will typically hold graduate degrees in science and/or science education.

PHILOSOPHIES OF TEACHING AND LEARNING BASED ON CERTAIN CONTEXTUAL FACTORS

At least 18 of the articles in the *Proceedings* contained philosophies of teaching that embraced certain predetermining factors that might impact a student's ability to learn certain subjects and processes. These articles include one by W.W. Tuttle (1920p27), who tied the ability to learn how to type to certain "native traits." He devised a controlled study to measure the degree to which students possessed those traits (or not). Native skills of an efficient typist, according to Mr. Tuttle included:

1. Quick motor action.
2. A keen sense of rhythm.
3. Ability to pay attention and be accurate.
4. A well developed memory span.
5. Ability to follow directions.
6. Ability to carry on the process of substitution. (Tuttle 1920)

When trait test results were compared with typewriting task success, certain attributes were found not to be necessary for typing, but useful for other tasks related to learning. These included: sense of rhythm, ability to follow directions, and memory span.

Note: care should be taken when drawing conclusions based on "native skills," since much can be learned with practice despite an initial showing of lack of skill. Wise and experienced teachers suggest that patience and hope spring eternal and may be rewarded with success in the end.

W.H. Batson of the University of South Dakota, in his article, "Measuring Human Ability" (1922p18), compared the necessity of a standard system of measurement in science to the necessity of developing a reliable intelligence test – to "measure human ability." With any instrument, there should be some understanding of its capabilities and limits because decisions made on the basis of standardized tests of all kinds can be destructive if the tests are not put into context with other factors.

> *On the whole it appears that the effort to replace opinion by measurement in our rating of work in various levels of education and even in determining ability or capacity for activities outside of school will increase and spread… There are many fantastic and even deceptive procedures parading behind the banner of educational science. Alleged scales are reported and used which measure the fact in question about as well as the noise of the thunder measures the voltage of the lightning. (Bateson 1921)*

Early attempts at development of measures of intelligence as predictors of student success as well as determining the value of students' ability to learn yielded conclusions that were fraught with misinformation, error and downright bigotry and sexism. Little understanding of the impact of developmental differences over time among students was considered.

By 1945, the predictions made by W.H. Batson in the *Proceedings* in 1922 had already come to fruition – more and more complex measures of student achievement were being used to assess which students were superior and so determined scholarship and the ability to do college level work. Batson's second article on the subject was included in the 1946-47 *Proceedings.* In this paper, he delves deeply into the nature of the tests, the objectives met by giving them, as well as how they were administered and graded. He includes a detailed report of findings for the period 1935-1944, illustrating tremendous increases in the number of schools participating in the testing program that encompassed questions on English, Social Studies, Science and Mathematics.

At that time, 32 percent of high school graduates went on to attend college compared with 43 percent of those who qualified for the final scholastic examination based on the scores of their first test. However, prediction of these students' success in college was not convincing – as grades are only incidentally a predictor of success. After college matriculation, no correlation between test scores and success is evident.

SCIENCE EDUCATION IN SOUTH DAKOTA: UNRESOLVED ISSUES AND CONTINUING CHALLENGES

This author, from the School of Education at the University of South Dakota, previously wrote about the history of science education in the *Proceedings* paper (2012p167) entitled "Public School Science Curriculum in Context: The Impact of Standard Reforms During the Last Two Hundred Years." In the conclusion of that paper the following appeared:

> *At a hearing early in 2007, Senator Edward Kennedy suggested that the way forward in science education lies in our knowledge of the past. He reminded us of events that have been forgotten in the present push for standards reform, "We did it after the Sputnik launch, [in 1957] when we trained a new generation of Americans in math and science. And we inspired millions more to greater and greater innovation when President Kennedy challenged us to send a man to the moon" (Abramson 2007). In 1958, Congress had passed the National Defense Education Act that gave a new science curriculum an infusion of more than a billion dollars when it passed. (Ezrailson 2012)*

As long as society changes and science education is then again "reformed," educational funding, as seen historically, will continue to be one of the biggest obstacles to science education quality and uniformity in South Dakota. Additionally, tension between the general public and science will continue, inviting political diatribe and new testing measures to again replace real and lasting reform. Tension and competition among colleges and online entities will increase, as the role of the "brick and mortar" college and university becomes more undefined and tenuous.

Perhaps, if the roots of today's challenges were examined with an historical lens, having an appreciation for the issues addressed, then an understanding of the solutions that had been attempted and worked, as well as those that had failed, might help us to formulate better remedies. As a result, the next generations of science education reforms, programs and partnerships between schools and colleges could blossom to yield excellent results.

This paper has drawn from our earliest beginnings and traced a path through papers addressing some persistent issues: the need for science education of the public, a look at specific and effective science teaching methods, and examined certain philosophies of teaching with their mitigating contextual factors. Some thoughts on possible solutions are offered and include: 1) educating ourselves (scientists and teacher) thoroughly on the issues (respecting all perspectives) to look for common ground and common language that the public will understand; 2) working together to prioritize steps to be taken (construct a timeline and action items) and to begin to spread our common message – consistently and persistently; 3) opening a continuous, and mutually respectful dialogue between all invested parties to formulate a strong message that includes achievable benchmarks and clear goals and; 4) most importantly, celebrating and publicizing (continuously) our successes and achievements to the public!