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Are there lessons to be learned by today's educational reformers from the fate of Dewey's pedagogical principles over the past century?

1. INTRODUCTION

One of the main points of this paper is to demonstrate that John Dewey's ideas on education are alive and well today, certainly in major efforts to reform school mathematics and science. A century ago he emerged as America's most influential philosopher. A powerful critic of the *status quo* in education, he was revered and reviled. For about the last fifty years his ideas have been denigrated, sometimes distorted, in broad educational circles (see Section 2). In Section 3 there is a brief discussion of the background of recent reform efforts in school mathematics and science. I show in Section 4 the strong similarities between Deweyan principles and major themes of the "standards" for school mathematics and science (which I shall call here the "math/sci standards"), formulated in recent years by leading professional organizations.[1-8] Then in Sections 5 and 6 I attempt to answer two questions raised by the renewed vitality of Dewey's ideas: Are there lessons to be learned by today's educational reformers from the fate of Dewey's pedagogical principles over the past century? Are the prospects better today than earlier in the century for the implementation ot those ideas in educational practice? My optimism about these prospects derives from the relevance of major themes of the math/sci standards to the needs of the changing industrial environment.

Dewey's educational ideas had radical implications for school organization and practices. In 1894, when he went to the University of Chicago as Head Professor of Philosophy, Psychology and Pedagogy, he established his so-called Laboratory School as an instrument to experiment with and refine his pedagogical principles. Although he insisted that it was not meant to be a "model" school for others to emulate, his influence and the power of his ideas were such that numerous schools were established, not only in the United States but abroad, which tried to carry out his ideas in varying degrees.

This "progressive education" movement flourished for several decades, particularly in private schools, but barely penetrated the great majority of American schools, those in the public school systems of the nation. Most of the resistance came from supporters of traditional educational practices, some from critics of certain aspects of his philosophy. Dewey himself acknowledged that many adherents of his philosophy had failed to appreciate the hard, detailed work required to implement new pedagogical principles (see Section 5):

> I think that only slight acquaintance with the history of education is needed to prove that educational reformers and innovators alone have felt the need for a philosophy of education. Those who adhered to the established system needed merely a few fine sounding words to justify existing practices. The real work was done by habits which were so fixed as to be institutional....It is, accordingly, a much more difficult task to work out the kinds of materials, of methods, and of social relationships that are appropriate to the new education than is the case with traditional education. I think many of the difficulties experienced in the conduct of progressive schools and many of the criticisms leveled against them arise from this source. [9, p. 29].

Having majored neither in philosophy nor education, I had not had occasion to read Dewey. In the late 50s (when my children began attending the local public school system) and in the 60s (when I served on its board of education), I would hear an occasional reference to progressive education, invariably derogatory. Thus, before this year it was my impression, when I thought about it at all, that hardly a trace remained of John Dewey's influence on American education. In spring 1995, however, I read the announcement of a conference on Dewey, [10] and one of the topics listed for discussion was "experiential education in and across the disciplines." In view of the attention given to experiential education in the math/sci standards, I decided to investigate how similar the major themes of these standards might be to Dewey's ideas.

In the course of this inquiry the only reference I found to such similarity is in a paper by Ratner: "John Dewey, E.H. Moore and the Philosophy of Mathematics Education In the Twentieth Century" [11]. The paucity of such references is consistent with Ratner's observation that since the 1920's, "Dewey and Moore have not been cited often in the reports of successive committees and commissions on mathematical education. Their seminal insights, however, have either been used or rediscovered and developed in new settings and situations..." [11, p. 114]. Here, besides comparing Dewey's ideas and the math/sci standards in some detail, I examine implications of their similarity.

2. CONFUSION ABOUT DEWEY'S IDEAS

At a recent mathematics conference where I spoke briefly on this subject, a questioner criticized Dewey's ideas, citing some "facts" which were simply wrong. Therefore I wish first to describe a few of the misunderstandings which are part of the Dewey legend in many people's minds. For example, he was criticized for advocating an adjustment ethic, the need to adapt oneself to existing social conditions. On the contrary, he emphasized repeatedly the importance of reconstructing or reshaping the social environment into a more desirable and ideal form.

Dewey himself contributed to this confusion, giving aid and comfort to his critics, for repeatedly he used the term "adjustment"—not in the usual sense, but in the sense of mutual accomodation. For example, he wrote early in his career that "every living form is dynamically not simply statically adapted to its environment. I mean by this, it subjects conditions about it to its own needs. This is the very meaning of 'adjustment'; it does not mean that the life-form passively accepts or submits to the conditions just as they are, but that it functionally subordinates these natural circumstances to its own food needs" [12, p. 51]. Later he remarked that, "We are also given to playing loose with the conception of adjustment, as if that meant something fixed—a kind of accommodation once for all (ideally at least) of the organism to an environment. But as life requires the fitness of the environment to the organic functions, adjustment to the environment means not passive acceptance of the latter, but acting so that the environing changes take a certain turn" [13, p. 8]. As one editor of his works has put it, "It is an irony of history that an adjustment ethic should be attributed to Dewey, for one of the concerns constantly manifest in his writings is that modern technological society is creating a more docile, passive individual" [14, p. xii].

More unjustly, he was attacked for suggesting that "education ought simply to cater to the needs and whims of the child" [14, p.xi]. The truth is quite otherwise. According to Dewey, "The fundamental factors in the educative process are an immature, undeveloped being, and certain social aims, meanings, values incarnate in the matured experience of the adult. The educative process is the due interaction of these forces" [15, p.182]. Conceding that "the kind of external imposition which was so common in the traditional school limited rather than promoted the intellectual and moral development of the young," he insisted nevertheless that the real problems of education "are not even recognized, to say nothing of being solved, when it is assumed that it suffices to reject the ideas and practices ot the old education and then go to the opposite extreme" of dispensing with the teacher's responsibility for planning and guiding the students' educational experiences [9, p. 22].

He stressed that "the greater maturity of experience which should belong to the adult as educator puts him in a position to evaluate each experience of the young in a way in which the one having the less mature experience cannot do....There is no point in his being more mature if, instead of using his greater insight to help organize the conditions of the experience of the immature, he throws away his insight" [9, p. 38].

3. THE MATH AND SCIENCE STANDARDS AND PREVIOUS REFORM MOVEMENTS

In 1989 the National Council of Teachers of Mathematics (NCTM) published "Curriculum and Evaluation Standardson School Mathematics," the first of several volumes expressing the consensus of professionals in the mathematical sciences "to guide reform in school mathematics in the next decade...in terms of content priority end emphasis" [1]. This was followed by the volumes "Professional Standards for Teaching Mathematics" [2], "Assessment Standards for School Mathematics," [3] and a number of booklets offering more detailed examples and guidance for various grade levels.

In a similar vein the National Research Council, following years of preparation and consultation with national science teachers organizations, has recently published "National Science Education Standards" [4], to offer guidance for school science. Taking their cue from these national trends (and often drawing from the "standards" documents), other organizations have formulated quite similar sets of principles; e.g., see [5, 6, 7, 8].

Since World War II there have been several "crisis" in mathematics and science education, starting with the American reaction to the launching of Sputnik. In school mathematics, for instance, the major reform thrusts were the "new math" (in the 1960's) and "back-to-basics" (in the 1970's). It is significant that these earlier reform efforts reached nowhere near the level of broad political and social recognition accorded to the educational concerns of the last decade. In the "education summits" of 1989 and 1996, convened by the nation's governors and attended by the sitting President and top business executives, particular attention was paid to the need to strengthen math and science education. (The leading figures at the 1989 conference were Governors Lamar Alexander of Tennessee and Bill Clinton of Arkansas.)

Willoughby has remarked that, "In 1894 the first national commisslon on mathematics education, known as the Committee of Ten," issued a report recommending, among other things, that mathematics be taught in a more integrated way rather than as isolated subjects, that more attention be given to realistic problem solving, and that there be "more emphasis on intuition and thinking" [16, p. 8].

"In the intervening hundred years," he goes on to say, "reports of committees, commissions, and others have regularly told us what is wrong with mathematics education and what we should do to fix it. Today the teaching of mathematics in most American classrooms resembles the teaching of 1894 more closely than it resembles the recommendations of the Committee of Ten or its many successors. What has gone wrong? Will this time be different?" [16, p. 8]. In my opinion it may well be different this time, and I give my reasons in Sections 6 and 7.

4. SIMILARITIES BETWEEN DEWEY'S IDEAS AND ELEMENTS OF THE STANDARDS PROPOSED FOR SCHOOL MATHEMATICS AND SCIENCE

The high degree of compatibility between Dewey's educational philosophy and major ideas of the math/sci standards may be noted by comparing statements on several aspects of pedagogy, as follows.

A major principle of current reform literature is that teachers should build on students' prior understandings. For example, it is urged that "in determining the specific science content and activities that make up a curriculum, teachers consider the students who will be learning the science. Whether working with mandated content and activities, selecting from extant activities, or creating original activities, teachers plan to meet the particular interests, knowledge, and skills of their students and build on their questions and ideas....Teachers are aware of and understand common naive concepts in science for given grade levels, as well as the cultural and experiential background of students and the effects these have on learning" [4, p. 30]. According to Dewey, "It is a cardinal precept of the newer school of education that the beginning of instruction shall be made with the experience learners already have; that this experience and the capacities already developed during its course provide the starting point for all further learning" [9, p. 74].

A broad theme of the standards is constructivism, a philosophy of learning in which "the focus is on 'allowing students to make meaning for themselves' rather than just barraging them with information" [8, p. 3]. According to the New York State Education Department's "Learning Standards for Mathematics, Science and Technology": "Students formulate questions independently...construct explanations independently for natural phenomena...seek to clarify, to assess critically, and to reconcile with their own thinking the ideas presented by others, including peers, teachers, authors, and scientists" [5, p. 4]. In Dewey's words, "The final problem of instruction is the reconstruction of [the student's] experience" [17, p. 74]. In this regard it is worth noting that the work of the Swiss psychologist and educator Jean Piaget on learning and cognition has profoundly influenced current thinking about cognitive science and intellectual development, and Piaget was a major contributor to the constructivist philosophy. "One of the most enduring and influential of Piaget's beliefs about cognition is that individuals actively construct their world...individuals operate with and on the environment, constructing their own perceptions as they assimilate new experiences into existing schemes and adapt the schemes to accommodate the constraints of the experiences" [18, p. 15].

In the 1989 NCTM "Standards" it is asserted that "'knowing' mathematics is 'doing' mathematics. A person gathers, discovers or creates knowledge in the course of some activity having a purpose" [1, p. 7]. A similar sentiment about knowledge in general was expressed by Dewey: "Knowledge is not something separate and self-sufficing, but is involved in the process by which life is sustained and evolved" [19, p. 87]. The editor of a volume of Dewey's writings has paraphrased Dewey's ideas as follows: "Thought is not theoretical, but a doing; for the solutions it proposes for the elimination of obstacles are not mere hypotheses, devised for intellectual or aesthetic satisfaction, but hypotheses to be tested in action, so that if they are successful, experience may move on to a further stage" [20, p. 15].

A core concept of Dewey's pedagogical principles was the transactional character of experience. "The nature of experience can be understood only by noting that it includes an active and a passive element peculiarly combined. On the active hand, experience is trying—a meaning which is made explicit in the connected term experiment. On the passive, it is undergoing. When we experience something, we act upon it, we do something with it; then we suffer or undergo the consequences. We do something to the thing and then it does something to us in return" [21, p. 139]. A similar notion, expressed somewhat differently, is found In the 1989 NCTM "Standards": "These goals imply that students...should be encouraged to explore, to guess, and even to make and correct errors...." [1, p. 5].

The most common buzzword of reform efforts in the past two decades has been "problem-solving". Dewey remarked that, "problems are the stimulus to thinking...growth depends on the presence of difficulty to be overcome by the exercise of intelligence" [9, p. 79]. The most effective learning, he thought, is that based on inquiry, on the application of intelligence to resolve a problematic situation. One of the New York State "Learning Standards" is "Interdisciplinary Problem Solving: Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions" [5, p. 61].

There is agreement not only on conceptual or philosophical aspects of education, but also on desirable modes of classroom behavior. Both Dewey and the math/sci standards emphasize the importance of communication between student and teachers and among students, and the value of students working together for common purposes.

Dewey criticized severely the traditional classroom scenario in which children were expected to sit quietly and learn by listening, for "The language instinct is the simplest form of the social expression of the child. Hence it is a great, perhaps the greatest of all, educational resources" [15, p. 43]. Similarly, in the 1989 NCTM "Standards" one ot the five listed "New Goals for Students" is "that they learn to communicate mathematically" [1, p. 5]. "This is best accomplished in problem situations in which students have an opportunity to read, write and discuss ideas in which the use of the language of mathematics becomes natural. As students communicate their ideas, they learn to clarify, refine, and consolidate their thinking" [1, p. 6].

Where the school work consists in simply learning lessons, mutual assistance, instead of being the most natural form of cooperation and association, becomes a clandestine effort to relieve one's neighbor of his proper duties. Where active work is going on, all this is changed.

Finally, Dewey has extolled the educational and social values of student collaboration. In the traditional classroom, he wrote, "The mere absorbing of facts and truths is so exclusively individual an affair that it tends very naturally into selfishness....Indeed, almost the only measure for success is a competitive one, in the bad sense of that term—a comparison of results in the recitation or in the examination to see which child has succeeded in getting ahead of others in storing up, in accumulating, the maximum of information. So thoroughly is this the prevailing atmosphere that for one child to help another in his task has become a school crime. Where the school work consists in simply learning lessons, mutual assistance, instead of being the most natural form of cooperation and association, becomes a clandestine effort to relieve one's neighbor of his proper duties. Where active work is going on, all this is changed. Helping others, instead of being a form of charity which impoverishes the recipient, is simply an aid in setting free the powers and furthering the impulse of the one helped. A spirit of free communication, of interchange of ideas, suggestions, results, both successes and failures of previous experiences, becomes the dominating note of the recitation" [15, p. 15 - 16].

Similarly various formulations of the standards advocate "cooperative learning" and elaborate for teachers various ways of guiding such efforts. For example, the "Science Teaching Standards" suggest that "using a collaborative group structure, teachers encourage...students to work together in small groups so that all participate in sharing data and in developing group reports. Teachers also give groups opportunities to make presentations of their work and to engage with their classmates in explaining, clarifying, and justifying what they have learned. The teacher's role in these small and larger group interactions is to listen, encourage broad participation, and judge how to guide discussion—determining ideas to follow, ideas to question, information to provide, and connections to make. In the hands of a skilled teacher, such group work leads students to recognize the expertise that different members of the group bring to each endeavor and the greater value of evidence and argument over personality and style" [4, p. 36].

5. LESSONS TO BE LEARNED

Certainly it is of interest to Dewey scholars that the math/sci standards contain major elements of Dewey's educational philosophy. This fact has practical implications, however, for a much wider constituency in the educational community. It is reasonable, for example, to ask whether we can learn any lessons about the prospects for current reform efforts from the problems of progressive education.

The best critique of progressive education that I have found is by Dewey himself. In 1938, forty years after he had begun articulating his objections to traditional education and his principles for a new educational philosophy, he reflected at length on how progressive education was being carried out [9]. In general he cautioned against a new orthodoxy: "It is not too much to say that an educational philosophy which professes to be based on the idea of freedom may become as dogmatic as ever was the traditional education which is reacted against" [9, p. 22].

Criticizing a common tendency of progressive teachers to define their practice "negatively or by reaction against what has been current in education," he cited three specific points of concern, namely, that "many of the newer schools tend to make little or nothing of

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organized subject-matter of study, to proceed as if any form of direction or guidance by adults were an invasion of individual freedom, and as if the idea that education should be concerned with the present and future meant that acquaintance with the past has little or no role to play in education" [9, p. 22].

The concern about neglect of the past does not appear to be relevant to mathematics and science education. For example, discussion of the Pythagorean theorem with a class of middle school children that I meet weekly immediately spans the millennia. In other words discussion of many topics in mathematics and science revolve around seminal results and insights bearing the name of a major figure in the history of the subject. The other issues, however, require further comment.

Dewey had not rejected the need for organized subject matter, but rather the way in which it was used in traditional education; similarly he had criticized the manner in which adult guidance was exercised in traditional education, not the need for such guidance. It is instructive to recall his view of the proper roles of these ingredients in his pedagogy, in what he called "the organic connection between education and experience" [9, p. 26].

An essential characteristic of Dewey's "newer education"—in fact, of any educational philosophy—is "continuity or the experiential continuum. This principle is involved in every attempt to discriminate between experiences that are worthwhile educationally and those that are not" [9, p. 33]. While the teacher must try to harness the student's attention and involvement by an interesting experience or activity—an enjoyable one, if possible—this is by no means sufficient. There has to be an end in view for the experience.

In Dewey's view an effective program requires the design (by the teacher) of a sequence of experiences, each building on the previous one, each preparing for the next. The program begins where the student is at, with the knowledge and conceptions (or misconceptions, for that matter) based on prior experiences; then the teacher has the responsibility of guiding the student through the process of developing and grasping new concepts to the point where the student has constructed (or reconstructed) the subject-matter for him/herself in an objective, organized form. Dewey observed sadly that many teachers in progressive schools focused on the design of individual stimulating experiences without giving adequate attention to the follow-up.

The lesson is clear. There must be an awareness of the need for continuity and planning on the part of those who want to teach mathematics or science according to the Standards' (or Dewey's) principles, especially on the part of elementary teachers, who are not in general math or science specialists. In the late 70's and early 80's, when the use of manipulatives in elementary mathematics was becoming increasingly popular, I remember seeing some teachers get excited about the fun to be had by teachers and pupils from working with manipulatives, without giving thought to the purpose, the mathematical insight to be achieved by the hands-on activity.

Happily those who developed and formulated the standards are aware of the teacher's critical role as educational guide and coach and the need for organization and continuity in guiding students' experiences. In the "Science Teaching Standards", under "TEACHING STANDARD A: Teachers of science plan an inquiry-based science program for their students," the first injunction for the teacher is to "develop a framework of yearlong and short-term goals for students" [4, p. 30]. Likewise, it is noted in the 1989 "Standards" that "it takes careful planning to create a curriculum!" [1, p. 11] and in the 1991 "Standards" that among "the important decisions that a teacher makes in teaching" are "setting goals and selecting or creating mathematical tasks to help students achieve these goals" [2, p. 5].

6. IS THE GROUND MORE FERTILE TODAY FOR IDEAS LIKE DEWEY'S?

Since education in the U.S. is a state responsibility, there is no official or uniform national curriculum; but the math/sci standards are being embraced broadly by state educational establishments. According to the National Science Foundation, "after the release of the NCTM standards in 1989, states began modifying their curriculum frameworks for science and mathematics. By 1994, twenty-four states had published revisions, and by 1995 still more states were in the process of publishing new or revised guidelines—thirty-seven in science and thirty-three in mathematics" [22, p. 34].

Official endorsement is one thing; implementation in the classroom is quite another (as was the case with the "new math"). The NSF reports that "based on the indicators presented here, the learning environment is becoming more like the one envisioned in the standards," but admittedly at a slow and uneven pace. "Teachers are beginning to implement many of the recommendations in the science and mathematics standards. In general, high school teachers are the group most resistant to reform. Despite recommendations to increase the use of hands-on activities and approach subjects in more depth [they] continue to rely heavily on lectures, and less than one-half assign long-term projects. In addition, most are not using computers for science and mathematics instruction. Generally, science and mathematics classes are poorly supported in terms of facilities and supplies" [22, p. 68 - 69].

The need for more and better computers is receiving much attention now from government officials and the media. This problem should be eased considerably in the next few years. But high school teachers seem to be more wary of change. As specialists in their subjects, they tend to be more comfortable with what they have been teaching in the past and how they have been teaching it. The greater receptiveness of elementary teachers to new approaches to math and science instruction may well be due to a felt need for better understanding in these areas, for a non-trivial percentage of elementary teachers are uncomfortable about their grasp of math and/or science and their ability to teach them.

Let me describe some of my own experience in this regard. Three years in a row, from 1979 to 1982, the Department of Mathematical Sciences at Rensselaer Polytechnic Institute offered an in-service course for elementary teachers, "Add Intuition to Math, Subtract Anxiety" [23], which embraced principles and pedagogical approaches similar to those formulated later in the mathematics standards [1, 2]. Not all the course participants were "math-anxious"; some were primarily interested in helping students so afflicted. But tests of the participants' mathematics skills, questionnaires about their feelings and attitudes toward math, and pre- and post-course assessments of their degree of math anxiety demonstrated that our course improved substantially, sometimes dramatically, the participants' understanding of mathematics and their level of comfort in teaching it.

The difficulty of carrying out any educational reform should not be underestimated. Apart from issues of technology and attitudes, many teachers, if not most, will need in-service instruction in the content and pedagogy of the standards; this will incur increased public expenditure, always an argument against change. For example, a news story about New Jersey updating its curriculum notes that, "The new standards brought an outcry from school districts that feel caught between new programs and demands to cut their budgets....While praising the idea of pushing students to learn more, critics said teachers would need new training" [24].

Yet there are substantial reasons for believing that ideas like Dewey's will in the next decade send deep roots into our educational soil. In answer to Willoughby's [16] question as to whether this reform movement will be any more successful than previous ones, I suggest that what is different this time is that the demands of today's workplace are very compatible with the math/sci standards.

A major role of the public schools is to equip young people with the skills they will need to make a living. In the early decades of this century mass production was increasingly characteristic of manufacturing. An historic development in this regard, in 1913, was the Ford Motor Company's first use of the assembly line, where workers had to perform repetitive tasks prescribed by designers and production engineers. One historian has remarked that, "Even more than previous manufacturing technologies, the assembly line implied that men, too, could be mechanized" [25, pp.10 - 11].

Industrialists viewing the assembly line as the new paradigm for production would scarcely seek critical thinkers or problem solvers for the factory floor.

'Look, it isn't a matter of doing a better job teaching what people used to need. We expect our workers to tackle problems they have never seen before, to work together and to communicate their ideas to others'

Dewey's ideas, however, were aimed precisely at encouraging children to maintain and exercise their curiosity and imagination. "Plato somewhere speaks of the slave as one who in his actions does not express his own ideas, but those of some other man. It is our social problem now, even more urgent than in the time of Plato, that method, purpose, understanding, shall exist in the consciousness of the one who does the work, that his activity shall have meaning to himself....How many of the employed are today mere appendages to the machines which they operate!" [15, pp. 23 - 24]. Would businessmen and other community leaders view such ideas as contributing properly to the preparation of young people for the world of work?

Today, however, cutting-edge technology has quite different expectations of production workers. Discussing production and innovation in the semiconductor industry, Kenney and Florida have written that, "In Japanese corporations...once the technology is designed and implemented, factory workers make continuous suggestions on how to upgrade and improve both the quality of the technology and the manufacturing process. . ." [26, p. 67]. In reference to the steel industry they use more dramatic language to describe how production workers have contributed to improving the efficiency of the "cold-rolling" process: "Nippon Steel has turned the cold-rolling of steel into a continuous process that takes less than one hour from start to finish. It achieved this by unleashing the collective intelligence of its workers" [26, p. 67].

What a conceptual change: from "men...could be mechanized" to "the collective intelligence of...workers"!

American corporations also envisage an altered role for production workers. "In the mid-1980's," according to Craig R. Barrett, chief operating officer of the Intel Corporation, "it became brutally apparent" to the U.S. semiconductor industry "that all the smart technologists in the world would not make this industry a success. We had to get down and vastly improve our manufacturing efficiency" [27]. An essential part in this task is now being played by a new breed of workers, usually with two-year degrees from technical schools or electrical engineering degrees; they "work with one thousand personal computers in the factory, searching for...'a plethora of small continuous improvements' intended to hasten production and improve chip yields" [27].

Finally, consider again the auto industry, where in 1913 the assembly line worker was to be an unthinking cog in the production machinery. In a *New York Times* article of April 21, 1996, discussing a huge new hiring spree by America's Big Three auto manufacturers, it was estimated that 170,000 new factory workers will be hired by Ford, General Motors, and Chrysler in the next seven years:

> The Big Three have...borrowed Japanese management practices, which emphasize teamwork and job flexibility on the factory floor...now that they are hiring again, they are putting quick minds ahead of strong bodies. [Applicants go] through a grueling selection process that emphasizes mental acuity and communication skills. All three companies have contracted with...a human-resources consulting firm...to screen candidates. The firm checks their reading and math abilities, manual dexterity and understanding of spatial relations....Those who jump that first hurdle are tested for drug use.Then, for about three hours, applicants are put in groups of four to six and given a task to complete while...consultants assess their ability to work together [28].

7. CONCLUSION

In trying to relate the demands of industry to the changes in mathematics content and pedagogy called for in the NCTM standards, Robert J. Kansky, associate executive director of the Mathematical Sciences Education Board, has suggested that the search for a new way of teaching math began because business and industry leaders complained that students were not learning what they needed to know on the job. "They were saying, 'Look, it isn't a matter of doing a better job teaching what people used to need. We expect our workers to tackle problems they have never seen before, to work together and to communicate their ideas to others'" [29].

Kansky's suggestion that it was pressure from industry that drove math reform is simplistic. As noted above, already in the late 1970's the widespread dissatisfaction of educators with traditional math curricula and teaching practices had given rise to many experimental programs around the country. Yet there is significant agreement between the emphases in the math/science standards and the capabilities being sought increasingly in new employees by major corporations.

A century ago, when John Dewey urged that American education stress the cultivation of such qualities, the message did not appear relevant to the needs and goals of the practical people, the leaders of business and industry. Now, however, we can expect that the new "standards" for school math and science, which incorporate so many of Dewey's ideas, will grow in favor with the educational community and the larger society because their time has come, because they are designed to encourage students' curiosity and imagination and other qualities which industry is finding increasingly valuable in its workers.

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