

Did Dewey Presage the 1989 National Council of Teachers of Mathematics *Standards*?

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The general theme of change in philosophy over time is due to traditional customs and beliefs failing to regulate society. This theme drove both John Dewey's Progressive Movement and the creation of the *Curriculum and Evaluation Standards for School Mathematics* (1989) by the National Council of Teachers of Mathematics (NCTM). The remarkable similarity in thought between Dewey's writings and the *Standards* is the basis for this paper. The point of view is from the *Standards* looking back to find Dewey's similar ideas. Although Dewey's views of mathematics *per se* are not extensively explicated, his overarching views on learning content resonate strongly with those of the NCTM document. There is common focus on the individual, learning as doing, developing power of each student, the use of worthwhile tasks, views on curriculum, and the need for more experienced teachers and peers to stretch and pull the student into arenas of exploration.

If John Dewey were alive today, what would he have to say about the standards movement? There are a number of types of standards under consideration, with a variety of characteristics. In particular, what would he think of the NCTM *C&E Standards*? What is the background of the NCTM *Standards*? Where would Dewey agree with the NCTM *Standards*? Where would Dewey disagree with the NCTM *Standards*? There are four main sections comprising the body of this paper: the issue, the epistemology, the impetus for change, and the vision. The idea of standards, what does it mean to know, why change, and what are the related goals?

The Idea of Standards

A standard may be defined as something established by authority, custom, or general consent as a model or example, a criterion by which judgments or decisions may be made (Ravitch, 1995). A standard may be both a goal and a measure of important materials, abilities or achievements. Standards with measurable performance objectives are prescriptive. Other standards are descriptive ideals of what is valued as a guide to local judgment and curricula, with more specific statements left for local determination and measurement. Content and performance standards may be either

prescriptive or descriptive. Surrogate standards regulate school accreditation, teacher certification, building permits, federal aid guidelines, and state school finance formulas. Opportunity to learn standards define the availability of programs, resources, and staff related to school delivery. In general standards describe what teachers or children should know and be able to do.

The whole standards movement is about helping schools decide what to teach. Standards give teachers professional grounds to make decisions about curriculum based on what is known about the learner, and what is appropriate for the learner. Teachers can exclude something from the curriculum if they feel it is contrary to the school mission or rules. Curriculum writing is both an inclusive and an exclusive act – writers have to choose what to include, what to let go, and the general rationale supporting those decisions.

Good standards are a guide to professional practice, a direction toward which to work, a source for professional discourse regarding shared practice, a conceptual framework for complex process and content areas, a source for research based criteria to guide curricular choices and pedagogical choices. Good standards are written using educational research, professional judgment, and the experiences of professionals. Good standards encourage high expectations for all students, are brief and easily understood, encourage a consistent core, promote equity, and enhance communication across disciplines. All standards are based on a stated or implied frame of principles or philosophy. The NCTM *Standards* meet this description.

There is a common approach in both the writings of John Dewey (1859-1952) and in the NCTM *Standards* published by National Council of Teachers of Mathematics (NCTM) in 1989. "This constructive, active view of the learning process must be reflected in the way much of mathematics is taught" (NCTM, 1989, p. 10). Dewey writes that a fully integrated personality exists when successive experiences are integrated with one another, and "can be built up only as a world of related objects is constructed" (1938, p. 44). Dewey was deeply involved with social issues of his day, especially school reform, and politics. His writing displays a lifelong rejection of dualisms such as fact and value, means and ends, thought and action, organism and environment, man and nature,

individual and society (Honderich, 1995). Dewey deplored the tendency to think in opposing dualities with no intermediate possibilities and searched for mediating ideas throughout his career. School practice in his time was polarized between strict traditional style and very free individualistic format. In the early 1980s school practice was facing strong parental push toward back-to-basics approach and content. "For NCTM the development of standards as statements of criteria for excellence in order to produce change was the focus" (NCTM, 1989, p. 2). The areas for change were content, pedagogy, and technology.

The NCTM *Standards* are descriptive visionary guidelines. They were formed by a commission charged with creating a coherent vision of mathematical literacy, and a set of standards to guide the revision of school mathematics curriculum toward the vision. NCTM defines a standard as "a statement that can be used to judge the quality of a mathematics curriculum or methods of evaluation" (1989, p. 2). For all grades the first four NCTM standards are Problem Solving, Communication, Reasoning, and Connections. Following these four process standards are nine or ten specific content area standards, differentiated in three grade bands of K-4, 5-8, and 9-12. There are also fourteen Evaluation standards covering three categories: 1) general assessment strategies, 2) information for teachers to use for instructional purposes, including a standard on disposition, and 3) the gathering of evidence regarding the quality of the mathematics program.

The NCTM *Curriculum and Evaluation Standards for School Mathematics* (1989) were written in response to calls for reform in the mathematics education community. After the California adoption rejection of all current textbooks in 1985, textbook publishers were concerned that various states would develop conflicting guidelines, hence textbook publishers wanted more general direction. The textbook writing and selection process was under scrutiny by the NCTM Instructional Issues Advisory Committee, with Jim Fey of the University of Maryland noting that the committee debated whether a professional statement by NCTM was needed to provide guidance for schools selecting textbooks. For NCTM leaders the increasing desire for improvement in mathematics education would couple with the need to create a demand on the part of textbook buyers for change, and motivate a shift from the framework orientation of the 1980 *Agenda for Action* (NCTM) to the notion of standards emerging in 1984. NCTM describes these standards as "value judgments based on a broad, coherent vision of schooling derived from several factors: societal goals, student goals, research on teaching and learning, and professional experience" (1989, p. 7).

The *Standards* outlined several major shifts from then current practice toward an emphasis on the empowerment of students. Classrooms should be seen as communities, not

merely a collection of individuals. Investigations and problem solving should include conjecturing, justification, and inventing, replacing the 'find the answer' mentality. Students should be using logic and mathematical evidence as verification, instead of simply accepting the authority of the teacher for mathematical truths. Students should be encouraged to use mathematical reasoning instead of rote memorization of procedures. These ideas of community, learning through experience, construction of knowledge both individually and socially, problem solving and reasoning, and teacher as facilitator rather than as font of knowledge are also seen in the prior works of Dewey.

The work of Dewey concerned securing the continuity he saw between philosophy and social and biological psychology. Dewey felt children were not empty vessels passively awaiting the pouring in of knowledge; rather, children were active centers of impulse, both shaped by and shaping their environment (Honderich, 1995). His logic was a theory of inquiry. What is needed is the application of intelligent inquiry, the self-correcting method of creating, testing and refining hypotheses grounded in previous experience. "Dewey's 'instrumentalism' defined inquiry as the transformation of a puzzling, indeterminate situation into one that is sufficiently unified to enable warranted assertion or coherent action; and the knowledge that is the object of inquiry is, Dewey insisted, just as available in matters of morals and politics as in matters of physics and chemistry" (Honderich, 1995, p. 197). There is a social context to inquiry that mediates both the terms of the initial problem and its solution, and being transformed by the inquiry process (Honderich, 1995). Dewey held to epistemological and moral fallibility – no claim of knowledge, moral rule, principle or ideal is ever certain or immune from all possible criticism and revision. This is quite in opposition to the absolutist Logicist and Formalist mathematical philosophies of the early 20th century. Dewey was tied to optimistic progressivism, which requires the cultivation of intelligent habits in individuals and a societal structure that encourages continuous inquiry (Honderich, 1995). Hence content standards make no sense without some expression of behavioral skills and attitudinal devices such as inquiry, thinking, and communication.

In setting his vision for reform, Dewey did not use a standards approach. His philosophy of education focused on the individuality of the learner and the primacy of the current experience, ideas intrinsically opposed to meeting standards. Dewey felt that requiring students to meet standards allowed the substitution of general and average performance levels for the "severe and definite judgment based on strong and weak points of the individual" (1916, p. 55). With regard to ethics Dewey was opposed to fixed ends, rules and universal standards because he felt a situational approach was better able to allow for changing conditions (Hickman, 1998). It

would seem this belief would also be valid for areas of a more content nature.

Dewey felt education happened in the present time, not isolated from the present as preparation for the future. Hence Dewey had a more relativistic sense of the value of a subject for the experience at hand. "The formation of proper standards in any subject depends upon a realization of the contribution which it makes to the immediate significance of experience, upon a direct appreciation" (Dewey, 1916, p. 249). Dewey's statements are consistent with the suggestion of the *Standards* that mathematics be based in locally chosen problem solving experiences to keep pace with the mathematical and cultural maturity of the students. The *Standards* further emphasize the active involvement of the student in learning, "guided by the search to answer questions — first at an intuitive, empirical level; then by generalizing; and finally by justifying (proving)" (NCTM, 1989, p. 10). This stance is consistent with the inquiry method of Dewey.

Dewey distinguished among results, ends and means, and aims. A result is simply an effect, as of an 'exhibition of energy'. An end marks off future direction and means mark off the present direction. An end completes or fulfills what went before it. Aim is a foreseen end, so aim gives direction to an activity. Aim requires careful observation of conditions to identify means and hindrances. Aim suggests proper order and sequence, and an economical selection of activities. And aim makes a choice of alternatives possible as one judges a best approach for the given conditions. Therefore, according to Dewey, acting with an aim means acting intelligently, to foresee and plan.

Aim implies orderly and ordered activity progressively compelling a learning process. The writers of the *Standards* would agree that mathematical activities should be worthwhile, educative as Dewey writes, and planned to coordinate with prior and post experiences. Dewey's means and ends are like present day objectives that are measurable and specific, and hence should be locally controlled to be responsive to local needs and conditions. The NCTM *Standards* agree.

The traditional practices against which Dewey railed are the same practices that prompted the calls for reform three-quarters of a century later. Dewey lists the tenets of traditional education, which in general emphasized the external forces and ignored the internal factors. The chief purpose of education is to transmit past knowledge. Subject matter consists of bodies of information and skills that have been worked out in the past. Content is taught with little regard to the ways in which it was developed or to changes that are likely in the future. "That which is taught is thought of as essentially static" (Dewey, 1938, p. 19). Subject matter and standards of proper conduct are handed down, therefore attitude of pupils must be 'docility, receptivity, and

obedience'. The general pattern of pupil-pupil and pupil-teacher interactions is sharply different from other social institutions, as is the pattern of organization: school room, time schedules, schemes of classification, examination, promotion, and rules of order. Books and textbooks are primary source of 'lore and wisdom of the past'. "Teachers are the agents through which knowledge and skills are communicated and rules of conduct enforced" (Dewey, 1938, p. 18). Moral training lies in forming habits of action in conformity with developed rules and standards. Moral training per se is not addressed by the NCTM *Standards*, however they discuss the related area of disposition, to which this paper briefly attends in a later section.

Dewey writes that the traditional school feels that the mind is illogical, and requires logical form to be impressed upon it via already organized knowledge presented in finished form from outside understanding (Hickman & Alexander, 1998). It is assumed that the logic will transfer to the mind, which will become logical by conforming to the external subject matter. Content is first analyzed into logical elements by the text or the teacher, each element defined, then the elements arranged in series or classes consistent with the principles of the content. Curriculum is reduced to outlines, diagrams and schematic divisions which are copies of adult logic. The memorizing of the formulation forces the child to 'stultify his own vital logical movement'. "It is evident from these examples that in such a scheme of instruction, the logical is identified exclusively with certain formal properties of subject matter; with subject matter defined, refined, subdivided, classified, organized according to certain principles of connection that have been worked out by persons who are expert in that particular field" (Hickman & Alexander, 1998, p. 275). Students react to this 'school' with lack of interest, inattention, procrastination, aversion to intellectual application, dependence on memorization and mechanical routine, and only a small understanding (Hickman & Alexander, 1998).

The second type of school is the other extreme, touting individuality and natural unfolding, giving free rein to impulses and desires without regard to intellectual growth. It also assumes the mind is naturally illogical because 'many minds are rebellious to the particular logical forms in which a certain type of textbook presents its material' (Hickman, 1998). Both schools make the same error of ignoring tendencies to a reflective and logical mind that occur in young children. Dewey writes of 'native curiosity', an 'innate disposition to draw inferences', and an 'inherent desire to experiment and test'. "The mind at every stage of growth has its own logic" (Hickman & Alexander, 1998, p. 276). Dewey felt his Progressive schools replaced custom with more reasonable and developmentally appropriate method of scientific inquiry.

What does it mean to know?

There is a clear intersection of thought between Dewey and the writers of the *Standards* on the issue of what it means to know. The *Standards* draw upon Dewey directly for his helpful distinction:

The first consideration in preparing each standard was its mathematical content. To decide on what is fundamental in so vast and dynamic a discipline as mathematics is no easy task. John Dewey's (1916) distinction between "knowledge" and the "record of knowledge" may clarify this point. For many, "to know" means to identify the basic concepts and procedures of the discipline. For many nonmathematicians, arithmetic operations, algebraic manipulations, and geometric terms and theorems constitute the elements of the discipline to be taught in grades K-12. This may reflect the mathematics they studied in school or college rather than a clear insight into the discipline itself (NCTM, 1989, p. 7).

Historically, Dewey found that "(S)cholastic conception of knowledge ignores everything but scientifically formulated facts and truths" (1916, p. 184). Later he continued, stating there is now an 'immense bulk of communicated subject matter'. Some consider facts and truths contained in encyclopaedias, atlases and other books as knowledge. "The statements, the propositions, in which knowledge, the issue of active concern with problems, is deposited, are taken to be themselves knowledge. The record of knowledge, independent of its place as an outcome of inquiry and a resource in further inquiry, is taken to *be* knowledge" (1916, p. 187). Thus Dewey clarifies his distinction between facts as a record of knowledge and personal knowledge in preparation for his new perspective on learning.

The view taken by both the *Standards* and Dewey is that knowledge is a dynamic and purposeful process. "A person gathers, discovers, or creates knowledge in the course of some activity having a purpose" (NCTM, 1989, p. 7). Knowledge has a purpose in the continuation of learning and in the gaining of further and higher order thinking skills. "(I)nformation is an undigested burden unless it is understood. It is *knowledge* only as its material is comprehended" (Hickman & Alexander, 1998, p. 274). Educative information is what grows naturally from some interest of the learner, fits into the existing knowledge base to increase its efficacy and deepen its meaning (Dewey, 1916). NCTM also feels that there are fundamental concepts and procedures that should be known by all students because "established concepts and procedures can be relied on as fixed variables in a setting in which other variables may be unknown" (1989, p. 7). However the emphasis is on 'doing' rather than 'knowing that' with an eye toward future use of the knowledge gained.

NCTM views 'knowing' mathematics as 'doing' mathematics. It is a consistent and recurring theme throughout the *Standards* documents. Dewey is very clear that "initial subject matter always exists as matter of an active doing, involving the use of the body and the handling of material", and the "knowledge which comes first to persons, and that remains most deeply ingrained, is knowledge of *how to do*; how to walk, talk, drive a horse, sell goods, manage people, and so on indefinitely" (1916, p. 184). While driving a horse may not resonate strongly with those of us born in the latter half of the twentieth century, his point is well taken. A score of years later, Dewey remarks "There is, I think, no point in the philosophy of progressive education which is sounder than its emphasis upon the importance of the participation of the learner in the formation of the purposes which direct his activities in the learning process, just as there is no defect in traditional education greater than its failure to secure the active co-operation of the pupil in construction of the purposes involved in his studying" (1938, p. 67). NCTM puts this idea in more vernacular terms. "Our premise is that *what* a student learns depends to a great degree on *how* he or she has learned it" (NCTM, 1989, p. 5, Author's italics).

According to NCTM, learning does not occur by passive absorption alone (1989); students begin a task with prior knowledge, assimilate new information, and construct their own meanings. From these experiences as outlined in the *Standards*, students should gain mathematical power. Mathematical power is the ability to explore, conjecture, reason logically, and solve nonroutine problems using a variety of methods (NCTM, 1989). Dewey agrees that past experience and prior knowledge are needed for drawing analogous suggestions to the present problem, otherwise, attempting to think is futile (1910/1991). Of course Dewey felt school should develop students' ability to think. Thinking should be connected with efficiency in action, and learning more about themselves and the world in which they live. "Information severed from thoughtful action is dead, a mind-crushing load" (Dewey, 1916, p. 153). This image of a static and burdensome load is clearly opposed to his view of knowledge as dynamic and ever more engaging process.

NCTM credits children entering Kindergarten with considerable mathematical experience, writing that a developmentally appropriate curriculum should 'capitalize on children's intuitive insights and language' to help them 'retain their enjoyment of and curiosity about mathematics' (1989). Dewey also claims there is meaning in the experience of the immature. The starting points are natural impulses and desires. Next is reconstruction of these, using inhibition of impulse through individual's own reflection and judgment. Stop and think. Recall the past, use senses to observe objective conditions, consider other courses of action, and plan one's activity coherently and comprehensively (Dewey, 1938).

"Thinking is thus a postponement of immediate action, while it effects internal control of impulse through a union of observation and memory, this union being the heart of reflection" (Dewey, 1938, p. 64). This is the general idea of self-control, which Dewey felt is the ideal aim of education (1938). Otherwise impulses and desires not under intelligent internal control are under the control of accidental circumstances. One could be a 'slave' to one's blind desires (Dewey, 1938). Regarding their understanding, children should be in control, not under control.

Both mathematical power and thinking begin with experience, an actual empirical situation. Experience is defined by Dewey as "trying to do something and having the thing perceptibly do something to one in return" (1916, p. 153). Thinking implies 1) a store of experiences from which to draw suggestions, 2) promptness, flexibility, and fertility of suggestions, and 3) orderliness, consecutiveness and appropriateness in suggestions (Dewey, 1910/1991). The beginner needs to be trained in the process of 'self careful examination, consecutiveness, and some sort of summary and formulation' of personal conclusions and reasoning (Hickman & Alexander, 1998). Students proceed through scientific insight of the materials and laws involved, and assimilate into their direct experience the ideas and facts shared by those who have had a larger experience (Dewey, 1916). "What he has learned in the way of knowledge and skill in one situation becomes an instrument of understanding and dealing effectively with the situations which follow" (Dewey, 1938, p. 44). Thus learning becomes a recursive event, spreading and spiraling toward more expert understanding and behavior.

Of course the immature mind is still in the process of gaining the organization and processes of the expert. Dewey notes that it is "absurd to suppose that the beginner can commence where the adept stops" (Hickman & Alexander, 1998, p. 277). This is why memorization of any existing 'record of knowledge' is generally unproductive and often counterproductive. The learner cannot get there from his or her existing frame of experience, hence such abstracted recorded knowledge is useless. "That which is strictly logical from the standpoint of subject matter really represents the conclusions of an expert, trained mind. The definitions, divisions, and classifications of the conventional text represent these conclusions boiled down" (Hickman & Alexander, 1998, p. 277). According to Dewey the word 'logical' has three levels of meaning: widely, any thinking intended to reach an accepted conclusion; narrowly, 'proof of a stringent character' following from premises according to approved forms; and 'systematic care to safeguard the processes of thinking so that it is truly reflective'. Thus logical thinking is the regulation of natural and spontaneous observation, suggestion, and testing, 'thinking as an art' (Hickman & Alexander, 1998).

Understanding and comprehension mean that parts are held in relation to one another, requiring reflection (Hickman & Alexander, 1998). Dewey feels education should cultivate reflective thinking, 'changing looser methods of thought into stricter ones whenever possible' (Hickman & Alexander, 1998).

Again, mathematical power is the ability to explore, conjecture, reason logically, and solve nonroutine problems using a variety of methods. In a broader sense, Dewey is saying the same thing. Students need to explore their surroundings, conjecture about the problems, develop logical habits of thinking, and use their knowledge as a tool for continued learning of both a social and content nature.

Why change?

In the mid 1980s California rejected the adoption of any current mathematics textbooks. Textbook publishers were concerned that various states would develop conflicting guidelines, hence textbook publishers wanted more general direction. The textbook writing and selection process was under scrutiny by the NCTM Instructional Issues Advisory Committee, with Jim Fey of the University of Maryland noting that the committee debated whether a professional statement by NCTM was needed to provide guidance for schools selecting textbooks. For NCTM leaders the increasing desire for improvement in mathematics education would couple with the need to create a demand on the part of the textbook buyers for change, and motivate a shift from the framework orientation of the 1980 *Agenda for Action* (NCTM) to the notion of standards emerging in 1984. NCTM describes these standards as "value judgments based on a broad, coherent vision of schooling derived from several factors: societal goals, student goals, research on teaching and learning, and professional experience" (1989, p. 7).

One common impetus for change for both Dewey and NCTM was the increasing pace of change in the world. In the 1970s the nature of technological advancements and global communication were providing mathematics with new possibilities for content organization and pedagogy. "For NCTM the development of standards as statements of criteria for excellence in order to produce change was the focus" (NCTM, 1989, p. 2). Forty years earlier Dewey contended that static aims and materials are opposite an acquaintance with a changing world (1938). The *Standards* were viewed as facilitators of reform.

There were three reasons given by NCTM for adoption of its standards: 1) to ensure quality, 2) to indicate goals, and 3) to promote change (1989, p. 2). More specific teaching standards were written and published by NCTM in 1991, followed by assessment standards in 1995. In addition sets of Addenda booklets differentiated by grades or topics were

created to provide experiences and assistance to teachers implementing the *Standards* in classrooms. A revision of the 1989 *Standards* was initiated in the mid-1990s and published in April of 2000.

Public dissatisfaction with schools is another common issue. In the time of Dewey conservatives and radicals in education were dissatisfied with the present educational situation as a whole (Dewey, 1938). According to Dewey, Progressive schools were products of discontent with traditional schools, which impose adult standards, subject matter and methods from above and from outside. Such methods are foreign to and beyond the reach of the experience of the immature children (Dewey, 1938). Instead, Dewey championed the method of science, which is experimentation carried out under deliberate control, engendered in the seventeenth century (1916). Experience is now a deliberate control of the action and of making conjectures and testing them. This is rational experience guided by aim, not the old experience guided by custom or impulse.

What are the related goals?

The *Standards* based its vision of mathematical literacy on the historical school goals of transmitting aspects of the culture, directing learners toward self-fulfillment, and providing opportunities for self-fulfillment. The shift from an industrial society to an information society changed both the aspects of mathematics and the concepts and procedures needed. The acceleration of innovation in technology and communications was an economic reality requiring new social goals. These included 1) mathematically literate workers, 2) lifelong learning, 3) opportunity for all, and 4) an informed electorate (NCTM, 1989). These will be elaborated upon in this section.

The tenets of Progressive schools followed from Dewey's interpretation of the method of science replacing custom. Their principles of operation included individuality, development from within, dynamic knowledge, free activity, everyday life requiring applied science, education through occupation (process versus product), means versus ends, and connection to past and future. These principles are woven into the structure of the *Standards*, and are further discussed as they arise.

The first social goal of mathematically literate workers deals with the relation of schools to business, industry, workplace, and community. In 1987 industrial mathematician Henry Pollack listed the mathematical expectations for new employees in industry: "The ability to set up problems with the appropriate operations; Knowledge of a variety of techniques to approach and work on problems; Understanding of the underlying mathematical features of a problem; The ability to work with others on problems; The ability to

see the applicability of mathematical ideas to common and complex problems; Preparation for open problem situations, since most real problems are not well formulated; Belief in the utility and value of mathematics" (NCTM, 1989, p. 4). Fifty years earlier, Dewey discussed the integration of science within the curriculum, writing "Contemporary social life is what it is in very large measure because of the results of application of physical science" (1938, p. 79). We have appliances using heat and electricity, prepare food using chemical and physiological principles, read with electric lights, ride in motor cars or trains using operations and processes of scientific enterprise (Dewey, 1938). Curriculum must adapt studies to the needs of the existing community life, intending to improve for the future. It must place essentials (experiences shared by the widest groups) first, and refinements (specialized group needs) second (Dewey, 1916).

The second social goal is that of lifelong learning in order for students can accommodate to change conditions through problem solving and by creating new knowledge in their lifetime. NCTM felt that similar standards should be developed for preschool and beyond high school level learners. Dewey also sees humans as lifelong learners, people who are constantly readjusting and expanding to be inclusive of experiences and consequences (1916). In a later book, he reiterates "Education as growth or maturity should be an ever-present process" (1938, p. 50), meaning always fixed on present problematics, which, of course, secures a better future.

The third social goal is opportunity for all, recognizing that our society cannot afford a society polarized due to access to knowledge. Dewey felt early preparation for later work life should be indirect, engaging in the active occupations that are pointed out by the needs and interests of the learners as they progress. Also, children should not be scripted into vocations too early, or think that they will have only one main interest, for such thinking could 'fossilize' their vision into too narrow a view. Educators should be urging children into a continuous reorganization of aims and methods (1916). Dewey argues for a general education for all, since one does not know what vocation a child may choose to develop later.

The last social goal is an informed electorate. Current issues involve interrelated questions that require interpretation, critical attention and often technological understanding. More than eighty years ago Dewey asserted that "(A) curriculum which acknowledges the social responsibilities of education must present situations where problems are relevant to the problems of living together, and where observation and information are calculated to develop social insight and interest" (1916, p. 192). An older Dewey was more specific, stating the applications of science have in large part produced the social conditions that now exist. The methods of science also give insight to present social issues,

and to the measures and policies through which a better social order can be formed (Dewey, 1938).

The four social goals of NCTM were translated into five general goals relating to mathematical literacy so all students: 1) learn to value mathematics, 2) become confident in their ability to do mathematics, 3) become mathematical problem solvers, 4) learn to communicate mathematically, and 5) learn to reason mathematically (1989). Each of these goals should be infused throughout the curriculum to support the experiences that lead students to develop their mathematical power.

The first literacy goal is that students learn to value mathematics. NCTM states that the computer has made quantification and logical analysis of data part of fields such as business, economics, linguistics, biology, medicine and sociology. Hence the mathematics curriculum must provide opportunities for students to develop understandings of the mathematical models and structures used by other areas of study (1989). Connections to everyday life require applied science, so knowing more mathematics leads to better life.

Dewey felt the changes in social life facilitate selection of activities that help intellectualize the play and work of school. Everyday life at home on the farm and in manufacturing utilize applied science, whether or not people are aware of it, which only strengthens the argument to instill this scientific method to enable people to work intelligently rather than blindly (1916). Dewey later wrote that students should be introduced to scientific subject-matter and be initiated into its facts and laws through everyday acquaintance with social applications. This leads to later understanding of the economic and industrial problems of present society, which are the products of the application of science in production and distribution of commodities and services. Therefore the processes similar to those studied in laboratories and institutes of research are part of the daily life of children, and children should be gradually led, through extraction of laws and facts, to experience scientific order (Dewey, 1938).

The second mathematical literacy goal is that students become confident in their ability to do mathematics. NCTM endorsed a core content structure for all students, though it recognized that not all students are alike. Students have different needs, interests, abilities, and achievements, but the opportunity to learn should be available to all students, in order to have productive citizens, and prevent a polarized society. "The image of a society in which a few have the mathematical knowledge needed for the control of economic and scientific development is not consistent either with the values of a just democratic system or with its economic needs" (NCTM, 1989, p. 9). Dewey also felt the need for all learners to participate in mathematics in order

to become better able to function in an increasingly technological world, and in order to be more informed citizens. Dewey cites Hogben's *Mathematics for the Million* as showing how mathematics could be treated as a mirror of civilization and as a main agency in its progress, and can contribute to the desired goal as can the physical sciences (1938). Hogben takes an historical perspective at first, explaining mathematical concepts from counting to calculus, while simultaneously teaching the reader what he calls the language of size. The basic idea here is the progressive organization of knowledge set in the social realm by Hogben. The book's aim was "to stimulate the interest and remove(s) the inferiority complex of some of the million or so who have given up hope of learning through the usual channels" (Hogben, 1937, p. xi). Hogben was of the London School of Economics, and wrote the book while in the hospital during a long illness. He wrote not as a specialist, but as a private citizen interested in education.

The third mathematical literacy goal is that students become mathematical problem solvers, in order to become productive citizens. The problems should range from relatively simple exercises done independently to large open-ended problems requiring group or whole class work for an extended period of time. Problems are the stimulus for learning; they arise when a given experience leads out into new arenas from current experiences (Dewey, 1938). Progressive education is different from traditional education because the conditions found in the present experiences should be used as sources of problems, whereas in traditional classes the problems are set from outside. But "growth depends upon the presence of difficulty to be overcome by the exercise of intelligence" (Dewey, 1938, p. 79). Hence it is the process of learning that is important in a world changing quickly, not an accumulation of facts.

Traditional education seems to be more product oriented as opposed to the more process oriented approach of *Standards*-based and Progressive education. Similarly, learning through texts and teachers is opposed to learning through experience. The latter is what Dewey calls education through occupation. Education through occupation: calls instincts and habits into play; fights passive reception; demands a progressive end goal with results; appeals to thought; requires observation and ingenuity to discover and solve problems. "In short, an occupation, pursued under conditions where the realization of the activity rather than merely the external product is the aim, fulfills the requirements which were laid down earlier in connection with the discussion of aims, interest, and thinking" (Dewey, 1916, p. 309). A student's calling provides the real impetus for an organizing magnetic basis for gathering information, ideas, skills, and the continuation of growth of knowledge. Dewey felt the "only adequate training for occupations is training through occupations" (Dewey, 1916, p. 310). Knowing is doing and doing is knowing.

NCTM argued against passive absorption and fragmented memorization, noting that students enter a situation with prior knowledge, assimilate new information, and construct their own meanings. NCTM further states that "ideas are not isolated in memory but are organized and associated with the natural language that one uses and the situations one has encountered in the past" (1989, p. 10). This integration of history, prior personal experiences and development of meaning is also discussed by Dewey. He feels that knowledge of the past is no longer an end, but rather a means. What has been taught should not be regarded as an end, a 'fixed possession' but rather as a means for opening new fields that make new demands on powers of observation and intelligent use of memory. Connectedness in growth is a guideline (Dewey, 1938). Acquisition of isolated skills and techniques by drill is opposed to gaining skills as means of attaining more direct vital ends (Dewey, 1938).

NCTM used two guiding principles for student activities: 1) activities should grow from genuine problem situations, and 2) learning should have active as well as passive involvement. NCTM believed "learning should be guided by the search to answer questions – first at an intuitive, empirical level; then by generalizing; and finally by justifying (proving)" (NCTM, 1989, p. 10). Further, problem situations should be attuned to the cultural and mathematical maturity of the learners. According to Dewey it is the educator's responsibility to do two things equally: 1) The problem must grow out of the conditions of the experience being had in the present, and it must be within the range of capacity of students; and 2) The problem should arouse an 'active quest for information and for production of new ideas' in the learner, which then become ground for further experiences and new problems (1938). This is a striking similarity of thought.

NCTM had been calling for more attention to problem solving since 1980 (NCTM, 1980), yet the implementation and interpretation of genuine problem solving varied widely. The intention was more clearly delineated by a later description of what came to be known as worthwhile tasks. Worthwhile tasks are based on sound and significant mathematics, knowledge of students' understandings, interests, and experiences, knowledge of the range of ways that diverse students learn mathematics. Such tasks engage students' intellect, develop mathematical understandings and skills, stimulate students to make connections and develop a coherent framework for mathematical ideas, call for problem formulation, problem solving, and reasoning, promote communication about mathematics, represent mathematics as an ongoing human activity, display sensitivity to and draw on students' diverse background experiences and dispositions, promote the development of all students to do mathematics (NCTM, 1991). Since problem solving was considered the

main vehicle for content development, such a heavy burden of responsibility for outcomes was not philosophically unwarranted.

Dewey also felt that problem solving methods permanently successful in formal education "go back to the type of situation which causes reflection out of school in ordinary life" (1916, p. 154). Such situations should not be routine or capricious, he wrote, but uncertain or problematic, yet connected with existing habits to evoke or enable a response (1916). There is a distinction between genuine and simulated or mock problems: "Is the experience a personal thing of such a nature as inherently to stimulate and direct observation of the connections involved, and to lead to inference and its testing? Or is it imposed from without, and is the pupil's problem simply to meet the external requirement?" (1916, p. 155). The general features of a reflective experience, according to Dewey, are: 1) perplexity, confusion, doubt, due to being in a situation with unknowns; 2) a conjectural anticipation – a tentative interpretation of the given elements, noticing or attributing patterns or tendencies; 3) a careful examination of what can be identified to define and clarify the problem at hand; 4) an elaboration of the tentative hypothesis based on the data gathered, for precision and consistency; 5) deciding upon a plan of action; and 6) testing (1916). Dewey pointed out that steps 3 and 4 separate mere trial and error from a distinctive reflective experience.

In 1989 NCTM pushed student experiences as vehicles for understanding, but did not take an 'active *only*' stance on student involvement. [The October Discussion Draft of the updated *Principles and Standards for School Mathematics* promotes the use of active verbs in describing student learning processes: examine, represent, transform, solve, apply, prove and communicate (NCTM, 1998)]. Dewey allows experience to have a passive component, and delineates acceptable implementation. Teaching with understanding of natural development always begins with situations which involve learning by doing (Dewey, 1916). Experience is an active-passive affair, not primarily cognitive, though mere activity does not constitute experience; experience must be consciously connected with its consequences. The measure of the value of an experience is in the perception of relationships or continuities to which the experience leads (1916). Again there is an almost organic relationship expected between school experience, knowledge, growth, and life outside school. "Children will develop habits of one sort or another in the course of their interactions with their social and physical surroundings, so if we want those habits to be flexible and intelligent, we must do our best to structure an environment that will allow and indeed provoke the operations of intelligent inquiry" (Honderich, 1995, p. 198).

The focus on habits of mind is further discussed by NCTM under Standard 10 for Disposition. This includes

confidence in using mathematics, flexibility in exploring mathematical ideas, willingness to persevere in tasks, interest, curiosity and inventiveness, inclination to monitor and reflect on their thinking and performance, valuing of the application of mathematics to everyday situations, and the appreciation of the role of mathematics in our culture and its value as a tool and as a language (NCTM, 1989). Similarly Dewey writes that the business of education is "to cultivate deep-seated and effective habits of discriminating tested beliefs from mere assertions, guesses, and opinions; to develop a lively, sincere, and open-minded preference for conclusions that are properly grounded and to ingrain into the individual's working habits methods of inquiry and reasoning appropriate to the various problems that present themselves. ... The formation of these habits is the Training of Mind" (Dewey, 1910/1991, pp. 27-28). Dewey makes a clear connection among interest, the formation of critical habits of mind, and the development of student power. "To have an interest is to take things as entering into such a continuously developing situation instead of taking them in isolation" (Dewey, 1916, p. 137). Interest means one identifies with the objects of the activity and which provide the means and obstacles to the realization of the activity. There is effort, an endurance and continuity of attention, required to complete a task; this is will. From will comes the development of power, or discipline. Dewey feels schools should contribute to the broad goal of improvement of social conditions by forming intellectual and emotional dispositions to do so. Interests and intelligence should be trained towards the purpose of improvement of social conditions. If the accumulation of knowledge is an end in itself, then education accepts the present conditions, and perpetuates them. "A reorganization of education so that learning takes place in connection with the intelligent carrying forward of purposeful activities is a slow work" (Dewey, 1916, p. 137). Certainly the decade 1989-1999 has borne out Dewey's commentary regarding the 'slow work' of educational reorganization.

The fourth goal for mathematical literacy involves learning to communicate mathematically. This means learning to use the signs, symbols and language of mathematics while reading, writing, or discussing ideas. Inherent in this process is a natural use of the language leading to the clarification, refinement, and consolidation of students' thinking (NCTM, 1989). Although Dewey does not address the particular needs of the mathematics community in any detail, he does recognize the social nature of knowledge. "All information and systematized scientific subject matter have been worked out under the conditions of social life and have been transmitted by social means" (Dewey, 1916, p. 191). This 'transmission by social means' includes the influences of students upon each other. "For every act, by the principle of habit, modifies

disposition – it sets up a certain kind of inclination and desire. And it is impossible to tell when the habit thus strengthened may have a direct and perceptible influence on our association with others" (Dewey, 1916, p. 357). So communication is assumed to be part of the classroom behavior, inherent in participation in experiences.

According to Dewey the quality of those experiences may promote attitudes that then operate to modify the quality of subsequent experiences (1938). It is this disposition toward scientific thinking, what NCTM calls reasoning, that raises the level of education beyond initial curiosity. The fifth and last mathematics literacy goal is to learn to reason mathematically, which encompasses the behavior of doing mathematics: making conjectures, gathering evidence, and building a supporting argument (NCTM, 1989). For Dewey, science "aims at a statement which will reveal the sources, grounds, and consequences of a belief" (1916, p. 230). This learning process "gives logical character to the statements". Logical characteristics are different from the chronological order of the learner's passing from a crude awareness to a 'more refined intellectual quality of experience'. Logical characteristics, abstraction, generalization, and definite formulation, belong to highly elaborate intellectual subject matter. Education develops the students' understanding of the logical organization of such content and the foundation for utilization of activities in school. This requires the development of higher order thinking skills necessary for reasoning and justification. Dewey notes learners must use analysis to select the means from the present conditions, and must use synthesis to arrange them to reach an intended purpose (1938). These individual reasoning skills are at the heart of his penchant for the methods of science as pedagogy.

NCTM uses the language of 'each student' in emphasizing the tenet of opportunity for all and the individuality of each student. Dewey likewise rejected imposition from above as opposite expression and cultivation of individuality (1938). He also favored development from within rather than formation from outside elements. "Mechanical uniformity of studies and methods creates a kind of uniform immobility and this reacts to perpetuate uniformity of studies and of recitations, while behind this enforced uniformity individual tendencies operate in irregular and more or less forbidden ways" (Dewey, 1938, p. 62). The word 'education' comes from the Latin 'educare' meaning to lead out, a meaning and usage found frequently in the writings of Dewey. To be educative, experiences must "lead out into an expanding world of subject matter" (Dewey, 1938, p. 87). To do this well, the teacher must have some knowledge of learners' prior experiences. Dewey cautions that for older students it is "harder to learn the background of the experiences of individuals, and harder to discern how to direct the subject-matters already contained in that experience in order to lead out to larger and

better organized fields (Dewey, 1938). The adult should be looking at what direction the experience is heading, and use insight to organize the conditions of the experience, judging and directing to allow the learner to benefit from the wisdom of the mature person (Dewey, 1938). This sentiment has an echo in the *Standards*. "Finally, our vision sees teachers encouraging students, probing for ideas, and carefully judging the maturity of a student's thoughts and expressions" (NCTM, 1989, p. 10).

Summary

Dissatisfaction with the traditional status quo coupled with a design for better education propelled both the NCTM and John Dewey in their respective reform writings. The pace of change in the world led to the necessity for lifelong learning to be a continual and recursive process instead of learning accepted as a collection of static facts. Underlying both Dewey and the *Standards* is the rejection of the *tabula rasa* notion. NCTM and Dewey operate from a Constructivist philosophical basis. The source of truth shifted from outside authority to internal verification through scientific and reasoned approach. Knowledge is a dynamic and purposeful process; knowing mathematics is doing mathematics. Learning should be embedded in activities and experiences which directly relate to the learners' lives. Prior knowledge of the learner must be considered in the effort of providing appropriate activities. Such experiences should be worthwhile and educative, leading to further knowledge. Schools should utilize a developmental approach with increasing sophistication of method and understanding presented as learners mature. The main goal of schooling is to develop the power of students to operate and contribute to society. Did Dewey presage the NCTM 1989 Standards? Yes, the reform agenda of Dewey is alive and well in the *Standards*.

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