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Experimentalism in Science Teaching and Teacher Preparation

EXPERIMENTALISMO EN LA ENSEÑANZA DE CIENCIAS NATURALES Y FORMACIÓN DOCENTE

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ABSTRACT

This paper explains the approach to science teaching prescribed by John Dewey. Dewey rejected the conventional lecture + recitation + test model of teaching as wasteful, because learners did not do anything, and thus could not learn from experience. He also regarded it as anti-democratic, because students did not contribute to the aims or processes of their lessons, and thus were learning to submit to domination. Dewey reconceived science education in terms of students engaged in voluntary action in pursuit of self-chosen ends in engaging learning environments. Teachers have three roles: (1) the design of the learning environments, (2) consultation with the learners to assist them in achieving their ends, and (3) connecting the dots - after learners have had sufficient experience with areas of study - by re-presenting the knowledge acquired in its logically organized scientific form. The paper concludes by considering the adaptation of Dewey's approach to today's Internet-augmented learning spaces.

Keywords: Dewey, democratic education, science education, active learning

RESUMEN

Este artículo explica el método de enseñanza de las ciencias naturales prescrito por John Dewey. Dewey rechazó el modelo convencional de conferencia + recitación + prueba de la enseñanza como un derroche, porque los estudiantes no hacían nada y, por lo tanto, no podían aprender de la experiencia. También lo consideraba antidemocrático, porque los estudiantes no contribuían a los objetivos o procesos de sus lecciones, y por lo tanto estaban aprendiendo a someterse a la dominación. Dewey reimaginó la educación de las ciencias en términos de estudiantes que participan voluntariamente en la búsqueda de metas elegidas por ellos mismos en ambientes motivadores para el aprendizaje. Los profesores tienen tres roles: (1) el diseño de los entornos de aprendizaje, (2) la consulta con los estudiantes para ayudarlos a lograr sus metas, y (3) la conexión de los puntos - después de que los estudiantes hayan tenido suficiente experiencia con un área de estudio, el profesor re-presenta los conocimientos adquiridos en su forma científica lógicamente organizada. El trabajo concluye considerando la adaptación del método de Dewey a los espacios de aprendizaje actuales, aumentados por el Internet.

Palabras clave: Dewey, educación democrática, educación científica, aprendizaje activo

I. INTRODUCTION

My topic today is democratic teaching and teacher preparation in science education. I start by noting, however, that there is no single unified theory, method or practice of democratic education. Democracy is a theme in many different, and at times contradictory, approaches to education. In some nominally democratic schools, for example, important decisions are made by students in school meetings. In others, the official curriculum features student participation in citizen protests. I will limit myself today to the distinctive *experimentalist* approach to democratic education developed by John Dewey in his magisterial *Democracy and Education,* now celebrating its centennial year of publication. I do not claim that Dewey's experimentalism is the one true method, the holy grail, of democratic education. Nonetheless, it remains a useful point of departure for science educators today.

Dewey conceived of democracy not so much as a political system but as a 'way of living' grounded in habits of *free action* and *open communication*. For Dewey, schools *could* be designed as means for cultivating habits of free action and open communication - habits in the sense of flexible dispositions that young people could then carry into their adult citizen roles- thus democratizing society. As he put it, schools could "endeavor to shape the experiences of the young so that instead of reproducing current habits, better habits shall be formed, and thus the future adult society be an improvement on their own."

In conventional schools children are told to sit down and shut up, to listen to teachers and learn their lessons. Dewey believed that conventional schooling was anti-democratic, preparing young people as subjects of domination. Instead of sitting down, he felt, learners should get up and move around - engaging in activities which stimulate them to form their own projects and ends and to think through means for achieving them. Instead of shutting up, they should be communicating openly and actively with one another and their teachers and other adults as they think and plan, act on and test their ideas.

Dewey's radical alternative to conventional education has been misunderstood, misrepresented, and misapplied. "Most of what has been said by and for educators in the name of Dewey has consisted of distorted shadows and blurred images of the original doctrine"(Schwab, 1959). So before turning to science teaching and teacher education, I want faithfully to outline Dewey's experimentalist approach.

II. EDUCATION

Action is End-Directed and Leads to Learning. Dewey begins *Democracy and Education* by noting that education is living, and living is *doing* - taking action directed to the achievement of *ends*. He adds that when we act, we also undergo - we get feedback about what works and what fails that leads to reflection and changes in our action habits. *Doing* is thus the most natural way to learn.

Learning from Communication. We also learn naturally by *communicating*. As Dewey puts it, "All communication … is educative." To receive a communication "is to have an enlarged and changed experience. " "Nor is the one who communicates left unaffected" (MW9: 8), for communicating requires "getting outside of (a situation), seeing it as another would see it, considering what points of contact it has with the life of another so that it may be got into such form that he can appreciate its meaning."

In comparison to learning by doing and communicating, Dewey notes, learning from formal school lessons is - however necessary - both artificial and secondary to these more natural ways of learning.

Action Takes Place in a Social Context. Each action is surrounded, Dewey notes, by thousands of others, with other people acting in pursuit of *their* ends. Behind a teacher teaching a lesson, there are legislative and administrative government agencies, textbook publishers, university science and pedagogy professors, school architects and builders, forest managers and paper manufacturers, and much else. Every action in every sphere takes place within and presupposes an interconnected dynamic social world.

Actions are Norm-Governed. The behaviors of all of these actors, moreover, are governed by social norms. In everyday life, actions are all hemmed about by norms related to *ways of doing things*. 'Setting the table', for example, is defined by rules about items are placed. If a child places dishes and tableware in a different arrangement, mother may say 'that's not setting the table, dear', referring to a norm governing *ways of doing things*. We establish habits as we learn to act in accord with these norms. There are no 'autonomous individuals' of the sort conceived by classical liberals. All individuality is social.

Occupations. Dewey refers to important life activities governed by normative ways of doing things as *occupations.* Occupations are hardly limited to *jobs* – the housewife baking a cake or caring for a child is just as engaged in an occupation as teachers, doctors or carpenters. Occupations in Dewey's sense are simply our characteristic ways of *occupying ourselves to some purpose*. For an infant to 'grow up' and take her place in society – any kind of society – she must learn to take part in many 'occupations' herself.

For Dewey, education in its broadest sense is the process of bringing a young person along from infancy to full participation in occupations of adult social life and beyond.

Dewey knows that in our dynamic technological society our ways of doing things change. The knowledge and skill embedded in every occupation changes; moreover, today's occupations can even disappear while new ones emerge. As a result we cannot prepare a young people for current occupations. But we can occupy them in activities requiring continual knowledge acquisition, thus establishing habits of practical knowledgeable effectiveness for whatever future adult occupations they choose.

Dewey's discussion of the role of occupations in school learning in *The School and Society* is worth quoting. He defines 'occupation' in its educational sense as any "mode of activity on the part of the child which *reproduces, or runs parallel to*, some form of work carried on in social life.' He notes that:

> The instincts which find their conscious outlet and expression in occupation are bound to be of an exceedingly fundamental and permanent type. The activities of life are of necessity directed to bringing the materials and forces of nature under the control of our purposes; of making them *tributary to ends* (my emphasis) . . . (The child) continually sees his elders engaged in such pursuits. . . He comes in contact with facts that have no meaning, except in reference to them.

Occupations and Science. This reference to "the materials and forces of nature." and the task of " making them tributary to ends" already hints at the centrality of science in modern occupations, and hence in 'education through occupations.' Observation, measurement, the selection of means based on causal hypotheses, consideration of results of action as feedback, are integral to acting within occupations. As he puts it:

> we cannot overlook the importance for educational purposes of the close and intimate acquaintance got with nature at first hand, with real things and materials, with the actual processes of their manipulation, and the knowledge of their social necessities and uses. In all this there is continual training of observation, of ingenuity, constructive imagination, of logical thought, and of the sense of reality acquired through first-hand contact with actualities.

Before the industrial period, children learned about nature and social life at home and in neighborhood communities - on the farm and in local workshops. This still happens in some rural areas today. In the industrial city, however, the settings for this natural form of learning no longer exist, and conventional school education provides no substitute. For Dewey education through school occupations is a means of recovering these natural learning opportunities. Learning through occupations lays the ground for subsequent more formal learning upon which mature scientific knowledge can be built.

Learning and Internalizing Social Norms. The way to bring young people into adult life for Dewey is to position them within occupations from childhood. In this way they become surrounded by, and incorporate within themselves, the basic causal maps of the natural world and norms of social life. Young children instinctively want to participate in human life and seek actively to join in and emulate. And "children are gifted with an equipment of the first order for social intercourse."

What young people *can do*, however, "depends upon the expectations, demands, approvals, and condemnations of others," particularly their parents and teachers. So as children join in and participate, their behaviors invite the application of social norms. As they really do *want* to join in, actually *hunger* to join in - and feel deflated and depressed if excluded. So they actively absorb these norms as their own. They become saturated with them; their "original impulses" are "modified," so that they are not just acting in agreement with others, but "in so acting, the same ideas and emotions are aroused in (them) that animate the others." By participating, they accept and internalize ends inhering in the activities; they want these ends to be realized, feel good when they are, and bad when they are not. They share ideas and feelings with others, and become highly attentive to the adjustment of means to shared ends.

The Role of Adults. Adults can bring children along by "setting up conditions which stimulate certain visible and tangible ways of acting," and then including the child in activities in these settings so that they "feel its success as his success, its failure as his failure." In this way children become "possessed by the emotional attitude of the group," and become "alert to recognize the special ends at which it aims and the means employed to secure success."

For Dewey, this is the key to teaching and teacher preparation in science. Teachers are designers of occupation-based activity areas - gardens, shops, labs, studios - as well as the structured activities in which young people take action and pursue ends - alone and in association with others. Science teaching consists, in the first instance, in designing and setting up school occupations promoting processes of observation, measurement and inference and subsequently, the acquisition and use of scientific knowledge.

Directing Learning Activities. Child and youth action is directed by its ends, Dewey says, not (directly) by adults. The young person cultivating the garden, baking a cake, designing a dress, or repairing a lamp, directs action by reference to the intended result. Adults act upon the young most effectively not by directing their action but by shaping and influencing its *settings* - the *physical setting* and the *normative environment* of 'expectations, demands, approvals, and condemnations.' This environment then imposes an "unconscious influence" that is "so subtle and pervasive that it affects every fiber of character and mind."

Education as Growth. As the young engage in the activities and occupations of social life, they come to grow into full membership in their groups. They do so as they acquire the knowledge, skills, and purposes of mature workers in adult occupations. And when they come of age and their elders retire or pass away, they simply take over these groups. In this way, social life continues through generations of change in membership.

But even after they pass into their adult roles, new members continue to experience life in new ways. Situations change. Scientific knowledge grows. New technologies emerge. Adults act and to undergo, meet with success and achievement but also with disappointment and failure. New occupations fall away and new ones emerge. Fortunately adults retain some measure of plasticity - "the ability to learn from experience, to modify actions on the basis of the results of prior actions" - throughout life. Some of these modifications lead to even further technical developments which may transform occupations - as the Internet has in our day transformed all occupations. In short people

continue to reconstruct their habits, and this entails not merely improvements in behavioral efficiency but periodic transformations of deep intellectual and emotional dispositions which in turn reconstruct social habits as institutions. The "net conclusion" as Dewey states it, is that "life is development, and that developing, growing, is life."

Education as Preparation. When we think of education as *bringing a child along to full participation in occupations of adult social life*, we may jump to the idea that education is *preparation* for the child's *future* - that is, training for already selected occupations. This idea can lead us to fill up the mind's of young people with today's adult knowledge – perhaps in a watered down version thought suitable for school students.

This, says Dewey, is a *big mistake*. Thinking of education as 'preparation' assumes that the occupational environment is static when it is in fact constantly changing. As noted earlier, however, we don't have a clue what future occupations will be, or the knowledge and skill they will require when today's school children become adults. "Life is development." If, however, we keep engaging growing young people in ever-changing occupations, demanding ever-changing skills, *throughout* the years devoted to education, they will *already* be acting capably *in* the future when they get there, with a wide range of intellectual and practical skills. If, on the other hand we try to prepare them for imaginary futures during their early years, we simply ignore the real possibilities for learning in each *successive present* as their lives unfold.

III. DEMOCRACY

So much, then, for education in the broadest sense – in any kind of society. What then is democratic education? What, in particular, is democratic science teaching and teacher preparation?

First we have to get clear on what we mean by 'democracy'. For Dewey, as we have noted, democracy is a *form of associated living* - a way people act as free individuals who form their own ends and develop their own means, and who communicate and cooperate with one another in groups.[2] So, just what forms of relationship and communication does Dewey regard as democratic? Dewey

[2] Of course the word 'democracy' also refers to processes for selecting leaders and deciding issues through voting. Dewey does not neglect this political dimension, but thinks free action and cooperative social

sees modern societies as 'groups of groups'. When we observe 'society,' what we actually experience are individuals belonging to many overlapping groups: ethnic, religious, occupational, political, and so forth. The groups overlap because they have diverse memberships: for example, a religious group is likely to have members from different ethnic, occupational and political groups. Further, group members share about many things beyond the narrow aims of that group. For example, people talk with church friends about their families, or local politics, or changing work conditions.

Existing social norms, however, often create barriers to communication and cooperation across ethnic, religious, gender and class lines. Dewey thinks that a society is more democratic to the extent that (1) people develop - through open communication - many shared interests with many members of their primary groups, and (2) there is rich sharing of information and ideas across all group lines.

When these conditions are met, new ideas and information about all aspects of living circulate across group lines so that each individual has the opportunity to acquire fresh resources for full development of their individual personalities and powers of individual and cooperative action. Opportunities for mutual understanding expand. Democratic societies are thus communities of "integrated individualities". This concept of democracy thus resonates with '*buen vivir,*' as explained by the Latin American social ecologist Eduardo Gudynas: "With *buen vivir*, the subject of well being is not the individual, but the individual in the social context of their community and in a unique environmental situation." [3] Conflicts between individuals and groups may persist, but mutual understanding makes discussion, negotiation and compromise possible, reducing the likelihood of violence in conflict resolution.[4]

relations are more fundamental.

[3]https://www.theguardian.com/sustainable-business/blog/buen-vivir-philosophy-south-america-eduardo-gudynas

[4]Dewey sees some degree of democratic social integration along such lines as necessary for sustaining political democracy, and thinks that the most important contribution of political democracy lies in its providing - through elections and campaigns - rich opportunities to broaden and deepen communications among members of different groups.

IV. DEMOCRATIC EDUCATION

Education on this conception, is itself democratic to the extent that free action, the enlargement of shared interests, and the broadening of communicative exchange across groups are built right into into the fabric of learning.

To render education more democratic than it is in the conventional school with its 'banking' methods of learning, thus requires a radical transformation of every educational commonplace, from aims and thinking to methods and subject matters. Dewey considers each in turn:

Aims in Education. In conventional education aims are imposed on teachers and students from without. In democratic education teachers design settings in which learners as free individuals in association with others project and pursue their own ends.

Thinking. Thinking in education then consists not in solving textbook problems, but in students finding and testing means to their own selected ends – in acts of observing, selecting, trying out, reflecting and documenting.

Methods. Method in democratic education, from the side of both teachers of students, consists not in learning and following mechanically prescribed steps, but instead in thinking – that is, "experimenting with methods that seem promising, and learning to discriminate by the consequences that accrue."

Subject Matters. In conventional education subject matters are predigested concepts and facts conveyed to learners to be memorized – 'banked' for later test performance. As such learners are not pursuing their own ends, but going through motions prescribed by others, the whole setup is "hostile to thinking." In democratic education, subject matters are simply materials – things to *do* something with in freely chosen actions in pursuit of ends, so they are directly conducive to thinking.

While teachers must possess deep understanding of logically ordered discipline- based subject matters, their job is not, at first instance, to 'convey it'. Rather, it is to establish settings with many and varied subject matters in this sense – organized materials for doing things together. These exist to engage learners, to call out ends, to stimulate and guide communication and action, and to give rise to thinking.

Stages of Subject Matter Learning. In accord with his distinctions between learning by doing, by communicating, and by learning formal school lessons, Dewey sets out 'typical stages' in subject matter learning:

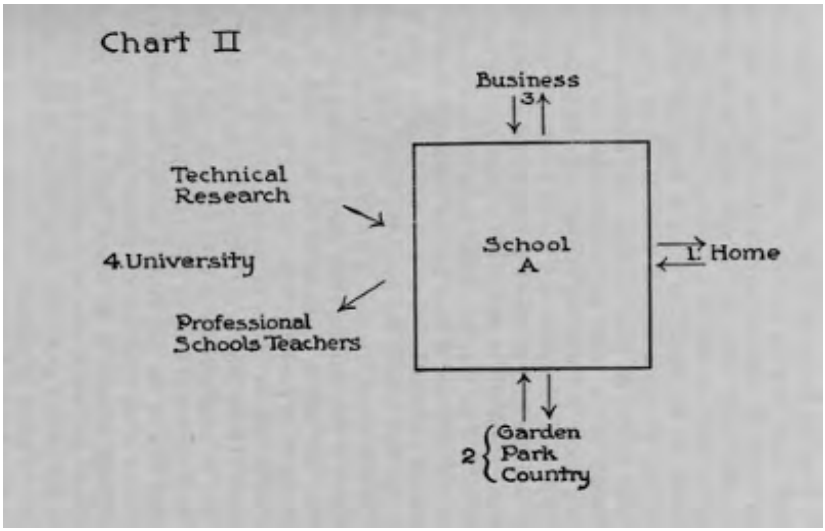
(I) In its first estate, knowledge exists as the content of intelligent ability—power to do. This kind of subject matter, or known material, is expressed in familiarity or acquaintance with things. (ii) Then this material gradually is surcharged and deepened through communicated knowledge or information. (iii) Finally, it is enlarged and worked over into logically organized material—that of the one who, relatively speaking, is expert in the subject.

Teachers *start* with the first two: learning by doing and communicating. They design information rich social settings for action, and structured activities within them. Each learner action in a social setting brings feedback that invites communication and further inquiries, and these in turn inform further actions.

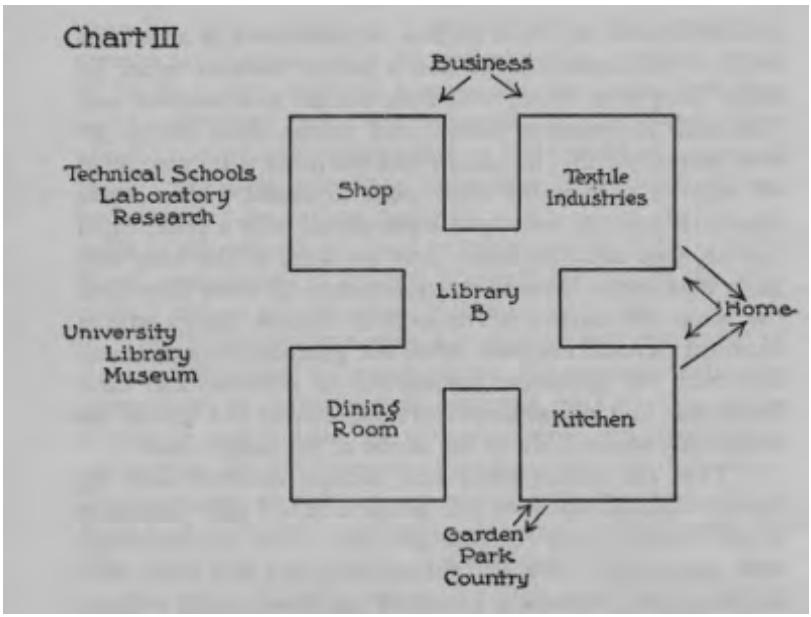
At certain appropriate phases - we call them 'teachable moments' - the inquiries may demand stage iii organized knowledge inputs. For example, a failure in the garden to grow flowers may lead to inquiries about the mineral content of the soil, which might in turn lead to learning first about soil chemistry and ultimately the periodic table. But the systematic knowledge in his scheme is not inert; it is called in and built upon to inform subsequent action and thought, and renders them both more intelligent.

V. THE EXPERIMENTALIST DESIGN FOR LEARNING

The following images from *School and Society* illustrate Dewey's approach. The first (chart II) shows the school in the larger society, surrounded by but walled off from (1) homes, (2) gardens, parks and country fields, (3) businesses, and (4) the university, with its technical and professional schools.



The second - (chart III) - Dewey's conceptual design for the elementary school - indicates potential relations between occupations in the surrounding community and in the school activity areas.



In Chart III, at outer portions within the building, we find various activity areas: the (i) kitchen, (ii) dining room, (iii) shop, and (iv) textile area - others can readily be imagined. The science-related learning potential of each of these activity areas is readily imagined. Some examples:

- In the garden, incidental to growing flowers, fruits and vegetables, students can learn through experience about the science of horticulture as well as soil science: the physical, chemical, biological, and fertility properties of soils, and how these properties affect the use and management of soils.[5]

- In the kitchen, incidental to preparing food to be served in the dining area, they can learn through experience about physical, biological, and chemical makeup of foods; the causes of food deterioration; and the concepts underlying food processing and preserving. [6]

- In the textile area, incidental to designing, making and using fabrics, they can learn about the chemical, physical and biological properties, and the human processing, of fibers, yarns, whole fabrics, and dyes, both natural and synthetic, including their uses in garments and household fashionings.[7]

- In the dining area, incidental to selecting and preparing appetizing and nutritious meal components and determining proper portions, they can learn about the effects of foods on metabolism, health, performance and disease resistance, as well as human behaviors related to food choices.[8]

- In the shop, incidental to learning to use tools to work with woods and metals and to repair and restore furniture and simple electrical appliances, they also can also learn about applied mathematics and physics.

Teachers first design and fit out the activity areas and design the structured activities where learners find opportunities for action and incidental learning. During activities teachers then consult with learners, guiding them toward questions and inquiries which deepen their scientific understanding.

[5] https://nces.ed.gov/ipeds/cipcode/cipdetail.aspx?y=55&cipid=87407
[6] http://www.ift.org/knowledge-center/learn-about-food-science/food-facts/about-fs-and-t.aspx
[7]https://www1.cfnc.org/Plan/For_College/Explore_Programs_and_Majors/Program_Keyword_Search/Program_Keyword_Search.aspx?id=MgFbNZecF0MuvuYIBesmAAXAP3DPAXXAP3DPAX
[8]http://ndfs.byu.edu/Programs/Undergraduate-Programs/Nutritional-Science/What-is-Nutritional-Science

The boundary between the school and its immediate periphery is porous, as is the boundary between the school area and the social world beyond. Thus, seeds and soil can be brought to the school garden from homes and nurseries, and foodstuffs from the garden can be brought into the kitchen. The boundaries within the school are also porous: food prepared in the kitchen can be brought into the dining room, while kitchen appliances can be brought into the shop for repair. Everywhere, there are explicit parallels between the occupations in the larger society and school occupations in the activity areas.

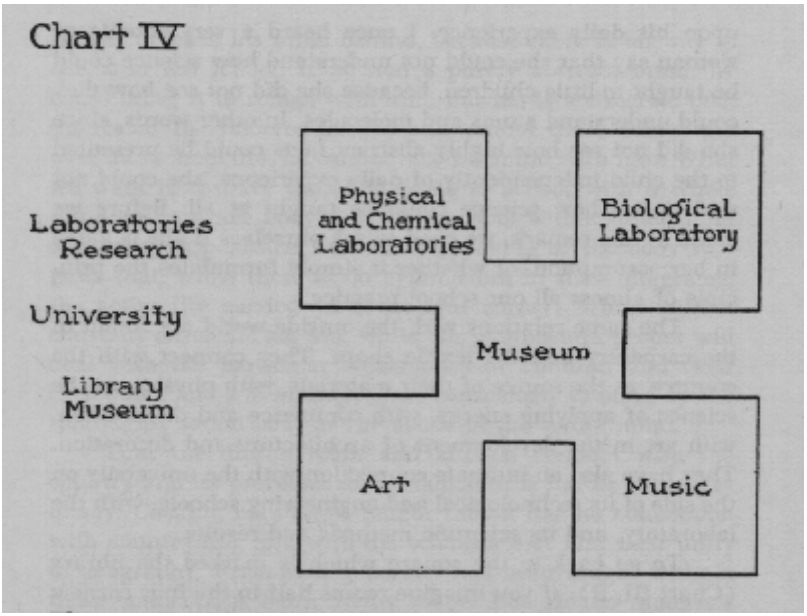


Chart IV represents the high school, with its laboratories and studios as activity areas, and its central information area in the library now augmented by a 'museum' of artefacts.

A current example of experimentalist secondary science teaching comes from Miami Florida, now affected by the Zika virus. Biology teachers on one school have developed a project to involve their lower secondary students in disease prevention.

In Miami, the teachers begin these 'biology labs' by asking students to report on what they already know about the Zika virus and the threat to the community. Once learners are engaged, teachers work with them further to

explore their understanding of the virus, how it spreads, and the damage it does. They also ask learners what they think they can do about this problem. This establishes a practical background within which students can form both learning and ameliorative goals.

This practical setting enables teachers and students to generate background knowledge and awareness regarding e.g., virology, insect reproduction, sexual transmission of diseases, epidemiology and public health. Students, using community and Internet-based resources, investigate these topics, guided by teacher consultants. Armed with their growing knowledge, the students suggest studies and make plans - for example, to try to eliminate standing water that creates mosquito breeding grounds, or to prepare multi-lingual brochures for parents explaining how to protect their children from Zika exposure. Working together, they set some provisional goals for their project. Meanwhile the teachers, as members of a professional community of practice, develop and apply evaluation criteria, document the project, and improve its design for subsequent groups of learners.

Teaching

In the experimentalist approach to science teaching there are three central roles for teachers: (1) design, (2) consultation, and (3) instruction. The *first task* of teachers is to *design* the activity areas and fit them out so learners will engage with subject matters and will project ends to achieve. In addition, teachers design the structured activities in which, to the largest extent possible, students shape their individual and collective ends. In their designs and consultations, teachers establish situations for group communication. By communicating with one another during the activities, learners build shared interests, form shared ends-in-view, and engage in collaborative thinking.

At the center of the school lies the library and museum. In the spaces between the activity areas and the library/museum are what Dewey designates 'clearing spaces'. As learners will frequently find their activities interrupted due to lack of clarity about ends or lack of know- how, the *second task* of teachers is to c*onsult with learners in the clearing spaces* - either providing direct assistance or sending them to the library/ museum to find the information they need to proceed on their own.

More didactic episodes of systematic instruction then become appropriate - but only at those times when the practical situation calls for them - when more systematic understanding is needed to advance the course of activity. *Notice: there are no spaces designated as classrooms anywhere in Dewey's model.*

Democratic Education and Democratic Society

In Dewey's model of democratic education, learners go through a protracted period of years in acting and thinking in information-rich and communication-rich social settings, engaged in occupations and pursuing meaningful ends. They think collaboratively - within and across group boundaries - about how to obtain these ends, and seek guidance and knowledge inputs from teachers and the library as necessary.

In this way they acquire habits of democratic living. As they grow through their school years, their school activities approximate the ever-changing occupations of the surrounding society. And when they come of age, and take over as adult citizens, that society *eo ipso* becomes more democratic simply because they, with their more democratic habits, take over.

VI. TEACHER PREPARATION AND THE UNIVERSITY

Dewey insists that school teaching is a university-based professional endeavor requiring systematic knowledge of the sort found in university disciplines and professional fields. Teacher training, as a result, must be established "upon the first and soundest basis by associating it with university ideals and methods (MW3, 325-6)." The university supplies both the content and the methods which inform science teaching.

Scientific subject matter content. Experimentalist teachers need the full possession of academic knowledge, Dewey asserts, to bridge the gap between the experience of the child and the cognitive aims of instruction in the specific school subject areas - ultimately that cognitive expertise relevant to adult occupational life. As we have seen, for Dewey the term "subject matter" stands from the perspective of learners for just the objects of (everyday) interests in school environments. But to the teacher, knowledge of subject matter must go far beyond the present knowledge of the students --its purpose is to "supply definite standards and to reveal. . . the possibilities of the crude activities of the immature'

(MW9:182). The academic disciplines, the branches of "formulated, crystallized, and systematized subject matter" are the teacher's "working resources, available capital" in the design of activity areas and structured activities, as well as in their consultations with learners. Robust disciplinary knowledge positions teachers to grasp "the *meaning* of the seeming impulsive and aimless reactions of the young, and to provide the stimuli to direct them …" (182). The over-riding goal of the science education process is "the development of what is already experienced into a fuller and more organized form, a form that gradually approximates that in which subject matter is presented to the skilled, mature person engaged in adult occupations" (LW13: 73-75). To succeed in this task the teacher needs to have the crystallized and systematized subject matter disciplines mastered and thoroughly available "at his fingers' ends (MW9: 183)" precisely so that he can attend *away* from it *to* learners and their efforts. Or consider this from *How We Think*:

Education that takes as its standard the improvement of intellectual attitude and method of students demands more serious preparatory training. . . a very wide and flexible command of subject matter -- so as to be able to select and apply what is needed just when it is needed.(LW8, 164); (the teacher's) intellectual preparation in subject matter. . .should be abundant to the point of overflow (LW8, 338).

And it is the scientific scholarship of the university, in its consummatory form as organized knowledge that equips the teacher for this attending away. For what is known in this sense is precisely "what is certain, settled, disposed of; that which we think *with* rather than that which we think *about"* (MW9: 196, emphasis Dewey).

The (stage i and ii) experiences which teachers organize in the activity areas bring to the fore predictable problems and irritations to be addressed by student thinking applied to resolve them. Teachers at these stages *attend* away from the contents of the scientific disciplines to the problem resolving efforts of their students in the activity areas: the garden, kitchen, dining room, textile area or shop, or mosquito mitigation project. But by moving student thinking in the direction of experimental reasoning, and driving home the advantages accruing to it, they are conditioning habits of informed, systematic collaborative problem solving, and thus preparing students for both deeper scientific understanding and

utilization. Then, teachers move to stage (iii) or discipline based instruction *as needed for tasks that arise*, drawing on their knowledge and experiences as members of the scientific community and their pedagogical content knowledge.[9]

University-based Method. The university is deeply implicated in the overall purpose of school studies - the spread of a scientific spirit throughout the occupations of the community. The university is the home of scientific inquiry, and university studies aim to imbue teachers with not merely the consummatory outcome of knowledge in the form of crystallized knowledge content, but also with the spirit of research inquiry, which they can carry into their adult years to expand the intelligence of the community as a whole. Educators who have not themselves acquired that spirit through their own research inquiries - in both science and pedagogical science - simply cannot pass it along to others.

To conclude this section: Dewey's experimentalist approach to teacher training focuses on building educational design and consultation skills - not just skills in instruction. Fortunately, many useful precedents exist in university-based design and business schools. Research in schools of education in turn should focus as much on design and consultation as on instruction. Teachers in training should be involved in all of these inquiries, so that they acquire research skills and attitudes to carry into professional life.

VIII. EXPERIMENTALISM AND DIGITAL TECHNOLOGIES

Obstacles to Implementation

The experimentalist form of education has not been widely implemented. It has been opposed by both traditional educators and by economic and political elites who oppose the very idea of free action - of young people thinking for themselves. But let us acknowledge three *inherent* obstacles to its implementation. First, in schools segregated by race and class, there is limited opportunity for significant communicative exchange across different groups. Second, the kinds of occupations we have been able authentically to reproduce within school settings have been limited. It is no accident that the school garden has become

[9] "Pedagogical content knowledge is a type of knowledge that is unique to teachers, and is based on the manner in which teachers relate their pedagogical knowledge (what they know about teaching) to their subject matter knowledge (what they know about what they teach). It is the integration or the synthesis of teachers' pedagogical knowledge and their subject matter knowledge that comprises pedagogical content knowledge" (Cochran, 1997).

a stock example of a Deweyan activity area - few other activities have fit the conceptual constraints as well. Third, this form of education requires levels of practical and theoretical knowledge even great teachers are unlikely to possess; it is an exceptional person who can respond creatively, on the spot, to all practical difficulties and connect them to relevant stage (iii) discipline-based knowledge. These considerations bring us to the new digital technologies. Can they help us overcome these inherent obstacles? If so, how?

Let's bring the Internet and open online courses to charts III and IV. [10] We can retain Dewey's conceptual organization of activity areas, clearing spaces and library/museum. But when each teacher and learner is armed with personal computing devices and Internet access, the 'library/museum' is now distributed throughout the school.

The networked situation changes the learning situation by (i) augmenting teachers' and students' powers of action, thinking, and communicative exchange, (ii) creating new possibilities for school-based activity, and (iii) providing ways of introducing general knowledge without turning to didactic teaching and undermining democratic education.[11]

Augmenting Powers of Action and Communication

The fundamental change in the networked situation is that everyone has new powers of learning, acting, thinking, communicating, and forming shared interests.

Learning by Searching. In the networked situation everyone can do Google searches for any topic of interest and locate powerful expert web sites on page one. Some will connect to library help desks where learners can obtain assistance, new ideas and additional links.

[10] I have argued in my recent book, Education 2.0, that rich use of the Internet is actually incompatible with the 'grammar' of conventional schooling; the knowledge resources and communication powers it offers sabotage the tight controls inherent in conventional pedagogy and classroom 'management'.

[11] "There is all the difference in the world whether the acquisition of information is treated as an end in itself, or is made an integral portion of the training of thought. The assumption that information that has been accumulated apart from use in the recognition and solution of a problem may later on be, at will, freely employed by thought is quite false. The skill at the ready command of intelligence is the skill acquired with the aid of intelligence; the only information which, otherwise than by accident,can be put to logical use is that acquired in the course of thinking." How We Think, revised edition (LW 8: 163).

Creating. With new digital tools anyone can make high quality images of videos and share them on personal or group blogs, Flickr or YouTube. Others can find, share, republish, emulate , alter, or mix them up to create something new.

Learning from Online Demonstrations, Tutorials and Activity Templates. While teachers have to consider learner background know-how in designing and fitting out activity areas, practical knowledge deficits can now be overcome through online tutorials and templates.

YouTube tutorials accessible to school students now exist on every conceivable topic related to the garden, kitchen, dining room and shop activity areas. Simple online tip sheets and action templates incorporating best practices exist as aids to thinking about almost every conceivable activity.

Joining Up. Clay Shirky notes that a social network is a cross between a 'tool' and a 'community'. Learners can use social tools to find and connect with others, engage others in their projects, join with others in collective action. Sal Paquet calls this "ridiculously easy group formation". [12]

This trait has allowed teachers to break out of their perpetual isolation. Teachers have been leaders in forming personal learning networks or 'PLNs'. Briana Crowley defines a PLN as "a vibrant, ever-changing group of connections to which teachers go to both share and learn." She adds that her PLN provides her with "a broader perspective on education—beyond my classroom, school building, state, and even nation. It is a blend of face-to-face and digital interactions with professional buddies and mentors …". [13]

Collaborating. Web 2.0 tools now enable educators across school, district, regional, and national boundaries to collaborate on materials, lesson demonstrations, and even the delivery of actual lessons; students can contribute their own insights and dialogue with peers, in so doing they can assist educators in understanding them as people and thus better serving their needs. And in this new culture of making and connecting, learners increasingly *expect* to connect and will turn increasingly away from learning environments which constrain collaboration.

[12] See the Wikipedia article on Paquet, online at http://en.wikipedia.org/wiki/S%C3%A9bastien_Paquet, accessed June 25, 2010
[13] http://www.edweek.org/tm/articles/2014/12/31/3-steps-for-building-a-professional-learning.html

I have recently outlined a plan to diminish class and race isolation in schools through collaborative networking efforts across municipal and school district lines. [14]

Acting Collectively. Author David Gauntlett argues that "through making things and sharing them with others, we feel a greater connection with the world, and more engaged with being more active in the environment rather than sitting back and watching." The connections made through online communities, social networks, blogs, and other Web 2.0 sites facilitate acting together for shared purposes, which Dewey considered the most satisfying form of human activity. Action is essential to complete the cycle of learning; once something is learned it becomes inert and stagnant unless shared, discussed, incorporated into our action schema, and used to achieve our various ends. Many of these ends are essentially public, requiring discussion and collective action.

New Activity Areas

Early in the Internet era we spoke of a separate world of cyberspace or virtual reality. But the Internet has now penetrated all occupations, so the distinction between the real world and cyberspace has collapsed. Instead of inhabiting real and virtual worlds, we are increasingly living in an integrated world of real virtuality. We work and seek work, shop and window shop, bank and invest, socialize and meet our friends and potential mates online. With the emergence of the Internet of things, medical diagnosis and treatment will increasingly move online, while 3-D print will enable integrated online design and manufacturing. As Dewey would be the very first to insist, we have no idea how human occupations will change even in the near term future. But there can be little doubt that however they change, they will be increasingly penetrated by the Internet. The Internet thus opens up many possible new activity areas.

Imagine for example a high school videography studio area. Imagine a school program offering training in marketing, negotiating with clients, writing, story-boarding, shooting, editing, and refining finished products in consultation with clients, and publicizing the finished videos in online media. Today all of these tasks can be performed on-line. Videography learners can acquire hours of authentic real world occupational experience, building current video capabilities while adjusting and adapting to market demands. Digital videography

[14] See Waks, 2006, p. 226-234.

training can readily be connected to academic learning in math, science, social studies, literature and the arts, and contribute directly to e.g., community based television, or production of social issue video documentaries. Many such examples can be imagined and implemented.

Organized Discipline-Based Knowledge

I close by considering possible uses for massive online courses or MOOCs for learning stage iii discipline-based science knowledge. The ever-present danger is that discipline-based teaching presents knowledge is isolation from its uses. It is an error, Dewey insisted (note 10) to assume that knowledge accumulated apart from use in the recognition and solution of a problem may later on be, at will, freely employed in thinking and problem solving. Dewey's design for learning (Section V) addressed this problem by eliminating spaces for didactic instruction from the school; all systematic instruction had to take place in or adjacent to the activity areas. MOOCs may provide a useful means for handling instruction,

MOOCs and General Knowledge Flipped in the Activity Areas. The transition from ad hoc micro-instruction in the activity areas to general, stage (iii) general knowledge, poses a particular challenge to Dewey's model of democratic education. Given his cautious skepticism about the value of school lessons, Dewey is surprisingly committed to a program of general education so all students gain hold of the discipline-based knowledge of the secondary school curriculum. In his model of teaching, however, the teacher is available primarily as a consultant when activity is interrupted, and acts by directing learners into the library to acquire chunks of knowledge needed to inform activity and move it forward toward its ends-in view. This piecemeal approach to knowledge acquisition does not seem likely to add up to organized logical stage (iii) subject matters as conveyed in in the conventional secondary school, much less to knowledge as possessed by experts.

MOOCs provide a possible avenue for approaching this problem. To the extent that we aim that all learners acquire something approaching the standard secondary curriculum in its logically ordered form but adapted to potential uses, MOOCs may be assigned for viewing - in the activity areas on students' digital devices, and applied in flipped lessons where the general knowledge is brought into play in practical applications.

MOOCs and Personalized Learning. Many tasks in the activity area, however, will be parcelled out to individuals, who will run into frustrations and obstacles not shared by everyone else engaged in the activity. In the garden area, for example, one student may be sorting seeds, another tilling the plot, and a third testing the soil for minerals. How, then, is the teacher to provide for relevant knowledge acquisition for particular learners? MOOCs provide one emerging possibility.

There are now 8400 MOOCs available – full academic courses on just about every subject and locatable in searchable databases. While early MOOCs were almost all college level courses with assigned start and end dates, many today are designed with younger learners in mind and are available on demand. Teachers can direct individual students or small groups to specific lessons as needed without bringing the activity group to a halt, and the specific lessons can then be folded into general knowledge – sometimes by assigning larger chunks of the same or related MOOC. MOOCs are also available for those students who take an interest, individually or in small groups, in advanced topics in any discipline or field. Teachers can 'flip' their classes by assigning MOOCs as needed, and using the knowledge content acquired in activities.

MOOCs and Diversity in the Learning Group. Finally, MOOCs can greatly enlarge the diversity of learner groups. Typical MOOCs have students from scores if not hundreds of countries. A reaction shared by teachers offering courses with both online MOOC and residential students has been how valuable the contributions of the overseas learners have been to the local students.

Summary

In this talk I have examined the experimentalist approach to democratic science teaching and teacher preparation advanced by John Dewey. For Dewey, education in its broadest sense involves learners from the youngest age in school occupations which reproduce or run parallel to adult occupations in the surrounding society. A democratic society is one that recognizes shared interests within groups as a principle of social control, and encourages mutual exchange among groups as a way of generating continual readjustments of social habit. Democratic education in turn is education that builds democracy – recognition of shared interests and communication across difference – directly into the fabric of learning. Teachers design activity areas and initiate structured activities in which young people – as free but integrated individuals – take on tasks and

pursue individual and collective ends they have selected and shaped themselves. Teachers then act as consultants, facilitating activity but also guiding it in the direction of enriched knowledge. They engage in systematic instruction, but always with an eye to its uses in activities where students are freely pursuing ends. In this model, educational design and consultation become as important in teaching as instruction, and learning to design and consult as important aims of teacher training as learning to instruct.

The Internet can serve democratic education by creating new and powerful means for learning, acting and communicating - even for forming diverse groups based on shared interests. It also enables, through real virtuality, a much broader range of authentic, real world shared activities within the school setting. MOOCs, in turn, provide means for introducing more systematic knowledge, on both individual and group levels, without requiring a turning away from activity areas to settings for didactic teaching, while adding greater diversity to the learner cohort.

Works Cited

Cochran, K. F. (1997, January 14). Pedagogical Content Knowledge: Teachers' Integration of Subject Matter, Pedagogy, Students, and Learning Environments. Research Matters - to the Science Teacher, No. 9702, https://www.narst.org/publications/research/pck.cfm

Dewey, J. *The Collected Works of John Dewey*, 1882-1953, ed. by Jo Ann Boydston (Carbondale and Edwardsville: Southern Illinois University Press, 1967-1991).

-------- *The School and Society, The Collected Works of John Dewey,* MW1: 1-111.

-------- *Democracy and Education, The Collected Works of John Dewey* MW9.

-------- *How We Think, The Collected Works of John Dewey* LW8: 106-353.

-------- *Experience and Education*, *The Collected Works of John Dewey* LW13: 1-63.

Schwab, J. (1959). The 'impossible' role of the teacher in progressive education. *School Review*

Waks, L. 2006. The Concept of a Networked Common School, in Michael A. Peters and D. John Freeman-Moir, eds., *Edutopias, New Utopian Thinking in Education*, Dordrecht: Sense Publishers.

-------- (2013). *Education 2.0. The Learningweb Revolution and the Transformation of the School*. Boulder: Paradigm.