Demystifying Constructionism

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Abstract

Many teachers and educational researchers are unclear about the meaning of constructionism or its implications for learning and instruction. This paper discusses a number of frequently aired educational dichotomies in order to situate and clarify the constructionist perspective. An elaboration of the contrary positions expressed by proponents of both sides of these dichotomies offers insights into the sense and purpose of constructionist ideas and approaches. It argues for the unique and valuable benefits of constructionism as a powerful learning paradigm.

There are several false dichotomies in education: *tradition versus reform, structure versus freedom, knowledge versus creativity, instruction versus construction*. They are false because they are often viewed as diametrically opposed adversarial positions. It's as though if you are on one side you can't possibly concede anything to the other. These strongly biased one-sided oppositions remind me of Oliver Selfridge's characterization of much of the thinking in current artificial intelligence research—that things must either be true or false—as *binary heresy*.

This either-or kind of thinking can lead otherwise intelligent people to say unintelligent things. For example, a few years ago a highly respected Boston economist, assessing the effects of computer technology in education, wrote: "Computers have proved to be ineffective in education. How do we know that? Because we've had computers in schools for several years now, and schools are still terrible!" An obvious response: books must *really* be ineffective, because we've had books in schools for much longer, and schools are *still* terrible!

Constructionists want to build a critical mass of citizens who reject false and misleading educational dichotomies, who support instead the creation of learning environments that integrate the constructive ideas on both sides of tradition and reform, structure and freedom, knowledge and creativity, instruction and construction. More broadly, constructionists seek to develop a culture of learning. We would like to develop a national thirst for promoting intellectual curiosity and creativity. This paper suggests an ambitious thrust toward that end: an intensive and sustained political and marketing campaign to build a groundswell of support for developing a rich variety of learning opportunities, both formal and informal, infused with constructionist ideas and activities. That is an awesome challenge. Large-scale educational change may not be possible during our lifetime, but there are schools and learning places where constructionist ideas and culture can flourish even today.

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A False Dichotomy: "Tradition" versus "Reform"

Two often-impassioned views of mathematics education underly the math wars issue, those held by the traditionalist camp and those held by the reformist camp. The former hold that school mathematics should focus on acquiring knowledge of basic number operations and calculation skills. The latter hold that mathematics education should focus on the development of critical thinking and problem-solving skills. *This is a false dichotomy!* Children need to be able to do both kinds of things. Of course they should have computational competence. But they should also acquire competence in mathematical ways of thinking and their application to things that matter in their lives as individuals and as citizens. We need to help children develop and employ basic reasoning skills while they are developing basic computational skills. These goals are not inherently opposed. We need to go *forward* to basics—not *back*—by moving toward a more comprehensive and powerful set of mathematical skills, all of which can be fostered by appropriate Logo programming activities.

If the sole goal of school math is to help kids acquire the ability to do sums, long division, and square root calculations, it might be argued that, with the introduction of calculators and computers, school math is no longer necessary.

This suggestion is analogous to the one in Jonathan Swift's brilliant 1729 essay "*A Modest Proposal: For Preventing the Children of Poor People in Ireland from Being a Burden to Their Parents or Country …"* Swift suggests that the Irish might ease their economic troubles and relieve their population problems by cooking and eating the children of the poor. In the same satiric fashion, though somewhat more benignly, we suggest that children should be removed from school math classes. Now that we have computers to do calculation, we no longer need school math. Children could be sent home sooner to do things that they find more enjoyable (and that are perhaps more intellectually beneficial than adding or dividing long strings of numbers.)

I'm being facetious. Of course kids need to learn calculation, but we can help them in new and better ways. In many schools, six or seven years are dedicated to teaching a superficial understanding of numbers and arithmetic operations. At the end of this protracted period, a large percentage of students fail to achieve even modest competence. What a terrible and unnecessary waste of time—all those years focused on calculation and the kids can't successfully emulate a calculator! Today, appropriate computer programming activities can make an enormous difference in the ease, enjoyableness, and effectiveness of learning number ideas and acquiring number manipulation skills.

Part of the problem is that the standard arithmetic algorithms are taught as cookbook recipes, disconnected both from the world of real mathematics and the world of kids. Boring, repetitive drills stamp out any flicker of curiosity and generate an indelible perception of mathematics as the realm of lengthy, ritualistic calculations. Our present method of teaching the subject conveys to our students the unmistakable (and lasting) impression that mathematics is both difficult and deadly dull. Rarely in the course of thirteen years of pre-college education are students given to understand that mathematics can be *fun.* Of course, *you* know that it *can*. Those of us in the Logo programming community have very specific ideas about how children's work with Logo can be used to motivate their development of mathematical ways of thinking while transforming their dislike of school math into fondness for the real thing.

Each of us has favorite areas for Logo-based interventions. Let me briefly share two of mine. One is the early introduction of combinatorics. This is the seminal area of mathematics that treats arrangement and ordering problems, the study of different ways of "jumbling" things. It's not the process of enumerating a given set of objects—what children learn as counting, but a natural and powerful extension of that—inductive enumeration—appropriately called *counting without counting*. Students are introduced to mathematically rich "counting" problems such as matching, merging, and sorting that involve the exploration and investigation of different ways of representing objects and operations. Working with such problems gives concrete meaning to powerful ideas such as equivalence, uniqueness, and completeness.

Another favorite area, an elementary introduction to transfinite mathematics, builds on kids' love of big numbers and their fascination with the idea of infinity, starting from the realization that there is no largest integer. This branch of mathematics extends the concept of counting in yet another way, leading to the development of powerful ideas such as incommensurability, countability, and orders of infinity. These topics are a great deal more interesting to kids than the standard school fare. The basic ideas and proofs are accessible fairly early and, through their exploration, children are exposed to mathematically rich ways of thinking.

Could topics like these be part of a *new* math curriculum in the constructionist context of student programming projects? Of course, a constructionist curriculum is not enough. None of this is possible without teachers who know the underlying mathematics, who are able to learn from their students, and who are comfortable about sometimes relinquishing control and ceding it to their students. Finally, it requires a trusting school culture and a political and social environment that support the challenges and risks of project-based learning, a willingness to trade the predictability of lock-step, scope-and-sequence, lesson-plan structures for the development of kids who are mathematically more literate *and much happier* in their math classes.

Another False Dichotomy: Structure versus Freedom

Students can greatly benefit from guidance and direction on assigned instructional tasks on the way to acquiring new knowledge and skills. But they also need opportunities for designing and constructing artifacts that test and extend their understanding. That is the heart of the constructionist learning perspective. Constructionism focuses on making the creation and sharing of new knowledge a primary goal. Without structure there is no freedom. And without freedom there is no foundation for development of intellectual growth and creative expression. This is true not only for education, but also for research and practice at professional levels in all fields.

The music of Johann Sebastian Bach exemplifies the powerful synergy between structure and freedom. Bach's Art of Fugue, for example, is one of the most emotionally charged works in all music, a transcendent model of creative invention. Yet, its overall organization and the interrelations among its musical structures and devices can be described (post facto) as a sequence of formal mathematical algorithms. The beautiful drawings of M.C. Escher, the most mathematically inspired graphic artist of our time, show the same creative integration of structure and freedom. Where else is such patently obvious draftsmanship technique, a readily trainable skill, transformed so eloquently into great art before our eyes?

An educational philosophy that often extols freedom while abhorring structure is that segment of the progressive school movement exemplified by A.S. Neill's Summerhill School in England. Summerhill was noted for its philosophy that children learn best with freedom from "coercion." All lessons were optional, and pupils were free to choose what to do with their time. The school was founded with the belief that "the function of a child is to live his own life—not the life that his anxious parents think he should live, not a life according to the purpose of an educator who thinks he knows best." For some troubled kids, the unstructured school environment can provide a nurturing, and perhaps corrective, experience. However, for kids who don't already come with their own learning agenda, it can be an ineffective intellectual experience.

Another example of freedom without structure is from Logo: One of the middle-school students who was introduced to Logo in one of our early teaching experiments, came to us and said "Now I know how to program. *Tell me what to program*." Students need to be motivated, to have their own purposes and drives. They need to learn how to make their vague ideas clear and precise. Work with programming can greatly aid students to express, debug, and reformulate their thinking. Along the way, they often need to acquire content knowledge that they can draw upon to concretize their mental constructs and support their constructions. This goes against the instinctive tendency of some constructivist colleagues for whom the very idea of an explicit instructional agenda is anathema.

Work with Logo can also exhibit *structure without freedom*. I have seen curriculum materials designed to teach Logo programming that are so tightly prescribed and circumscribed, that they bring to mind the “do it by the numbers, dot-to-dot” paper drawing exercises for young children. In one case, in a Logo teaching sequence in a New York City school, students were told which commands to enter for a given procedure, line-by-line, from To all the way to End. They were then instructed to run “*their*” procedure, after which they were told, “Look what you’ve discovered!”

A Misleading Dichotomy: Instruction versus Construction

The distinction between knowledge instruction and knowledge construction serves to highlight the important contrast Seymour Papert draws between *instructionism* and *constructionism* (Papert and Harel, 1991). This dichotomy exposes the profound shortcomings of the all-too-common practice of school instruction that provides students virtually no opportunity for knowledge construction, e.g., for designing and building artifacts that test and extend their knowledge. Constructionism is not a rejection of instruction. Learning requires both instruction and construction. They are mutually supportive learning components, intimately joined throughout the learning process. Instruction is often both a useful precursor and a useful successor to construction.

Michelangelo, one of the greatest constructionists, learned the basic skills of his art by being exposed early to stonecutters and masons, and by apprenticing as a painter to the great artist Ghirlandao. He was initially assigned mundane tasks such as copying the works of his master. Even Picasso, the personification of originality and invention in art, trained himself by copying old masters at the Louvre, like generations of painters before and since. One learns to become oneself by the discipline of appropriating the knowledge of others as a prelude to forging new paths. Once a student has learned to replicate and assimilate the work of the expert he is better positioned to finding his own way.

Instructionism is the extreme case of instruction without construction, i.e., without enabling students to make the knowledge their own, to “*own*” it and move forward to take on new expressive challenges. Unfortunately, instructionism all too often focuses on *schooling* as opposed to *learning* (yet another dichotomy!) Constructionism—making knowledge construction a primary goal of instruction—is what those of us in the Logo community strive to achieve in our teaching and our own work. Along the way we learn from our mistakes. That’s why debugging is so valuable. We try, as Thelonius Monk so profoundly put it, to make “the *right* mistakes.”

There is, however, a distortion of constructionism that rejects instruction altogether and extols learning without teaching. For some educators, including many instructional technologists, “teacher-proof learning” seemed an attractive alternative to poor teaching and weak instructional methods. And, indeed, we admire autodidacts—“self-taught” highly accomplished persons—as exemplars of ostensibly instructionless learning. But the notion that most individuals can dispense with instruction as a key component of learning is wishful thinking: It simply doesn’t compute! Learning requires shared interactions between (and among) children and their teachers. Sometimes, during these interactions, the children teach and the teachers learn. Programming experiences can provide a powerful mediating role.

Another False Dichotomy: Revolutionary Change versus Incremental Reform

Why is this a *false* dichotomy—surely, revolution is the opposite of reform? Aren't they polarities? For a long time, the Logo movement has been (somewhat simplistically) characterized as consisting of two warring camps—the reformers and the revolutionaries. Those in the BBN Logo group were labeled reformers, because we believed that Logo would ultimately make significant inroads toward school reform. The MIT Logo group, led by Seymour, called for a fundamental restructuring of education, a political and social (though non-violent) revolution.

I share the revolutionary perspective—that *is* the goal we should work toward. But I have somewhat different views about what should be done to advance that goal. When will constructionism become a standard component of educational practice in schools? Not significantly in our time, and certainly not in most schools as we know them. But let's be realistic. Schools are going to be around for the foreseeable future. De-schooling will not occur during our lives! Should we abandon working with schools? If not, what should we do to foster constructionist learning? Like many of you, I believe in continuing to work within the current school world with tools like Logo that support constructionism. Large-scale school change may not be possible during our lifetime, but there are schools and learning places where the constructionist philosophy and culture can flourish today.

We'd like to help children make a serious commitment to becoming good at something that they have to work at, that takes time, and that requires a significant investment of thinking. We'd like them to become practitioners, actively engaged in some discipline or craft, and sharing their work with others (Feurzeig, 1988). We'd like to bring the culture of practitioners into the classroom. Toward this end, we can promote initiatives for developing apprentice learning, not only in the arts but also in science and mathematics, under the guidance of practicing professionals. The effort could draw upon the potentially enormous resource of retired mathematicians, scientists, engineers, and teachers in these areas, who have the time and interest to participate, who love their subject, and who can engage effectively with kids in fostering shared learning activities and experiences.

It would mirror the pre-college music education model in which young students spend significant time at a conservatory—perhaps several hours on Saturdays over a period of years—not only learning to play an instrument but also participating in a comprehensive education program—performing in choral and instrumental ensembles, studying music theory, and engaging in composition—on the path to becoming complete musicians.

Constructionists seek to develop a culture of learning. We would like to initiate a major effort toward changing the negative image of learning and creating a groundswell of support for revolutionary educational change. We seek to develop a national thirst for promoting intellectual curiosity and learning, particularly in mathematics and science where the image problem is most notable (Goldenberg, 2007). We want to build a critical mass of citizens who reject false and misleading educational dichotomies, who support instead the creation of learning environments that integrate the constructive ideas on both sides of tradition and reform, structure and freedom, instruction and construction.

That is an awesome challenge. We need to champion a radical transformation of current perceptions of the nature and worth of learning—a transformation that will build a powerfully supported national demand for the development of a rich variety of learning opportunities, both formal and informal. The endeavor would require an intensive and sustained political and marketing campaign. It would employ the full range of broadband communications media, engaging as advocates leading national figures—celebrities with wide popular appeal and influence, including movie, music, sports, and television stars, as well as other nationally known icons. It would also require the participation of skilled media artists, working in close collaboration with constructionist researchers and educators to create new and compelling learning activities.

Ambitious thrusts like this pave the way to significant educational progress, perhaps not in our time, but for our children or grandchildren. Increasing numbers of Americans are concerned about the poor quality of early education. The concern is not only about the failure of early mathematics and science education. It is also about the failure to support the preparation of informed and intelligent citizens. We seek to foster the development of a generation of young people who are thoughtful about their lives, their intellectual development, and their social responsibilities, and who understand the sense and purpose of the learning ideas we hold dear. Constructionist learning activities can have a powerful impact on these developments and contribute greatly to advancing these goals.

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