Invent to Learn: Making, Tinkering, and Engineering in the Classroom.

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This is a review of the book of that title by Sylvia Sylvia Libow & Gary Stager, which first appeared yesterday at Education Review. As the author of the review I am cross-posting it here because I believe it may be of interest to many who will encounter it here.

> *This book doesn't just advocate for tinkering or making because it is fun, although that would be sufficient. The central thesis is that< i>children should engage in tinkering and making because they are powerful ways to learn. (p. 3)*

Those words from the introduction lay out the premise around which this interesting book is organized. The authors make clear that they are talking not merely about
regular classrooms as a place of learning, but also anyplace where learning may be taking place, for example clubs and summer camps, neighborhood hangouts and community centers. Similarly, for this book a teacher is any adult who works with young people in a learning capacity.The authors lay out the book with the intent to

> *attempt a progression from the big ideas of the giants of education on whose shoulders we stand towards the specific things teachers can do to encourage those ideas today. (p. 4)*

Thus the authors begin with "AN INSANELY BRIEF
AND INCOMPLETE HISTORY OF MAKING" in Chapter 1, go through chapters on learning, thinking about thinking, concerns about how to use projects and how to teach in this context, to the nuts and bolts of making, from the "STUFF" one will need, student leadership, using a MAKER DAY approach to "Share the fun of making with everyone." They provide some practical suggestions of how to convince others of the approach, how teachers can "learn to do an teach things that didn't exist when they went to school" and conclude with an extensive list of resources (current at the time the book went to press) such as "Websites, books, kits, software, online stores and more" (pp. 4-5).*please keep reading*

In some ways this book is hard to review. On the one hand, the authors want to persuade the reader that their perspective is important and correct. On the other, they simultaneously want to provide something that can serve as

a key resource in the implementation of the approach for which they advocate, even recognizing that specific resources can quickly become obsolete or that the links could go dead. That is an inherent problem in producing in book form a meta-resource much of whose most valuable content is the links to online resources.

Let me start by offering several disclosure that might be relevant to how you interpret my review. First, I am neither a scientist nor a technologist. As a classroom educator, my primary focus is on Social Studies of various kinds. Thus in some ways I might seem an improbable choice to review this book. Yet there are several aspects of my own background that are particularly relevant, which I will dispose of now.

1. Much of the book is on the use of computers. Before becoming a Social Studies teacher I spent 20 years of my adult life earning my living with computers, and while my specific knowledge is dated, my understanding of how to use computers is not. It is worth noting that I entered the field with a background not in math, but in music. Thus when I offer comments about teaching all students about how to use and direct computers, I have a basis for doing so.

2. Much of my teaching has been in STEM settings. I taught for 13 years at Eleanor Roosevelt High School in Greenbelt, MD, which has a nationally known Science and Technology program, and as of the Fall of 2013, I will be teaching at North County High School in Glen Burnie MD, which has an active STEM program. At ERHS most of my students were in the S&T program. At North County, half of my courses will be in the STEM program, courses on policy, media, and research and data analysis. Both high schools produced national winners of the Intel Science Fair. I have an understanding of the interrelationships between STEM and non-STEM education.

3. The idea of a hands-on approach well predates our interest in STEM education. It was certainly a key part of the approaches of Maria Montessori and John Dewey, of Frobel and Pestalozzi (as the authors acknowledge on p. 13), and of many approaches to the learning of things like mathematics, for example, The Math Circle developed by Robert and Ellen Kaplan. It is also very applicable in many of the social sciences, such as having students DO history merely than read about it.

Let me return to the book. First let me make clear that I highly recommend it. For those who want an understanding in the words of the authors, I can also point at this piece at Middleweb (a site dedicated to education at the Middle School level), which also provides some interesting real world examples.

As to the book itself: as noted above, the authors emphasize that the general approach is not new. It is also well-based in our understanding of human development and of how the process of learning actually occurs. In their first chapter the authors recapitulate the relevant educational history and theory to place what they are saying in an historical context. They also remind us of the original hacker ethic in the computer world, in which the term was one of approbation and not of either disapproval or denigration. After all, the original hacker approach was to use the tools available – in that case hardware and software – as a means of exploring, understanding, and shaping the world on one's own.

I have previously mentioned that my background is in music. Those who seriously study music study the creative process, not merely by analyzing and performing the works already created by others, but by making attempts at creations of their own. Even those who do not become professional musicians, either as performers or as composers, nevertheless are part of a society in which music can more easily flourish. And there were a significant number of composers who supported their passion by other means, among them the American Charles Ives (insurance), and the Russians Alexander Borodin (Chemistry) and Nikolai Rimsky-Korsakov (who was a Naval Officer for the early part of his composition career before he devoted himself fulltime to music). We see similar patterns in poetry – William Carlos Williams was a pediatrician and T. S. Eliot worked for a long time in a publishing firm. I mention this history because the authors are aware that some might dismiss the maker movement as a waste of time, because most of our students will not – at least in the estimation of some – ever make use of the experience. The authors emphasize the contributions made historical to science and technology by those who were amateurs. Second, we cannot as educators know who might turn out how if we do not give them the opportunity to

explore – sometimes with guidance, sometimes very much on their own. This notion underlies much of the progressive and constructivist approach to education, with which the authors are fully in tune. Let me offer several brief quotes from this first chapter that illustrate where the authors are headed:

> *Kids view the ability to print their own toys, tools, and models with a sort of blase attitude described by Alan Kay's adage that, "Technology is anything that wasn't there when you were born. " (p. 28)*

> *The maker ethos values learning through direct experience and the intellectual and social benefits that accrue from creating something shareable. (p. 29)*

The authors, who thoroughly explain the importance of the life, work and thought of Seymour Papert to the maker movement, conclude this first chapter with this brief paragraph:

> *This book is intended to be aspirational. Like Papert, we believe in kid power and know that teachers hold the key to liberating the learner. The values, tools, and activities of the maker movement enrich and accelerate that process. (p. 30)*

As a non-scientist, I can nevertheless remember enough of my own childhood and seen enough of that of young nieces, nephews, and children of good friends, to recognize that children are natural scientists. The maker movement for which this book advocates attempts to utilize that, as well as the natural tendency towards imagination and desire to play to empower children with respect to our rapidly changing world.Other than preventing a partial outline, I have not yet gotten beyond the early portion of this book. I could proceed from here to do a more traditional review. I will not, because this book needs to be approached with a non-traditional mindset if one is going to gain the greatest value possible from it. I also want to encourage you to explore it thoroughly, to play with the ideas, to "make" of it the meaning you can for yourself. On that let me note
– I am a constructivist educator by inclination
– so are the authors

But I do not want to leave you bereft of further knowledge. So instead, let me offer a few quotations that very much caught my attention, then conclude with a few observations of my own.

> *When we allow children to experiment, take risks, and play with their own ideas, we give them permission to trust themselves. They begin to see themselves as learners who have good ideas and can transform their own ideas into reality. (p. 36)*

> *When school favors hard mastery over soft mastery, we implicitly ask some children to ignore their own best instincts. We figuratively tie one hand behind their backs. (p. 37)*

> *When we encourage children to build with sand, blocks, paint and glue, we are simply asking them to take what they know and apply it to the real world. In the truest sense, children are natural engineers and we can create classrooms that celebrate this fact. (p. 39)*

> *All design starts with an idea. But spiraling, iterative design does not require that the entire project be planned at the beginning. (p. 49)*

> *Some may find it hard to believe, but for many people who love math or science, making things work is a poetic experience. Combining the arts with STEM means that children can express themselves in even more variations. Making produces experiences in which children realize such truths. (p. 55)*

> *Students are quite skilled at figuring out what teachers want so that they can get through their day as efficiently as possible. Coaching students out of this complacency will take time and will be a challenge. Take care that you are not telegraphing your expectations. (p. 79)*

> *Teaching is not testing. Deep learning is possible even when adults abandon prejudices about the outcome of a project. The emphasis should be on process and on creating the conditions in which learners grow. (p. 82*

> *Crayons and paint can and should co-exist with digital tools. Old media can be digitized and merged with computer graphics in ne forms of visual art. Low-cost drawing tablets bring precision and tactile aspects of hand-held tools to the creation of digital images. (p. 85)*

> *In the late 1980s, the education community stopped speaking of computing as a verb and shifted towards "technology" as a far less specific field of study. This shift requires less of teachers and pays fewer dividends for learners. Replacing computing fluency with computer literacy is like sacrificing orchestra for music appreciation. (p. 131)*

> *Creating a classroom makerspace is an opportunity to give students ownership of their own learning as they explore their own passions. Continually ask yourself, "What can my students do instead of me doing it? How can my students be agents of change rather than objects of change?" (p. 175)*

Each of the foregoing quotes I have selected is embedded in chapters of practical worth. Trust me, the amount of useful resources is hard to imagine. There are tons of practical suggestions, ways of addressing concern, illustration of the use of specific pieces of software and hardware, and so on. This book is thus both a wonderful practical resource and something that presents an aspirational approach that address issues well beyond those normally considered in discussions about STEM education.I would argue that one key takeaway for me was the clear understanding that for STEM education to be achieving its real goals our approach to educational policy will have to be very different than what we have been seeing over the past several decades. It is clearly insufficient merely to insist upon ever more math and science courses that are deadly dull, do not invoke student interest, and seem to have little focus beyond increasing scores on tests so that we can claim that somehow we are doing "better."

While I was in the midst of reading this book, I emailed Dr. Stager to tell him how excited I was to read it. In fact, my decision to take my forthcoming position, where I will be teaching both Social Studies and STEM, might well not have happened had I not read this book. On a personal level I found it of great value, even though I will never have to as a teacher concern myself about the proper use of computer printing in a maker space. Part of what is exciting is to see the clear exposition of how scientific and related learning can be done within the framework of a

constructivist approach to education and learning. As a teacher I want to see my students empowered in all their learning.

Perhaps the most telling words in the book, at least for me, occur not at the end, but on p. 56. It is with those words I will conclude, after reiterating the following: if you have interest in how best to do STEM education, if you have interest in how we shape educational policy, if you care about student involvement in their own learning, you should read this book, and make sure others read it as well.

> *For those of us who want to change education, the hard work is in our own minds, bringing ourselves to enter intellectual domains we never thought existed. The deepest problem for us is not technology, nor teaching, nor school bureaucracies – it's the limits of our own thinking.*

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