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FOOTNOTES

Innovation and Economic Growth: Lessons from the Story ENIAC

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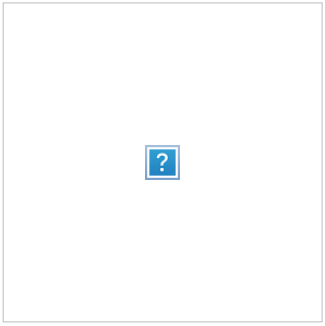
Program on Teaching Innovation



Rocco L. Martino

Of all the various ideas that have been advanc
and world economies, one of the most domina
innovation, and the creation of new products a

What is innovation; and what are the factors th

We can't teach people to innovate–if we could
or artificial intelligence program that would inn
encourage it, provide funding, and promote ac
can and should establish the environment to e
innovators and recognize and reward innovati

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Teaching the History of Innovation

Innovation means a new way of doing somethi incremental, radical, and revolutionary change processes, or organizations. [1] Essentially ther innovation: (1) radical–e.g., vaccination, fuel ce instead of chrome on a car, cell phones, the in revolutionary–leading to disruptive technologi nuclear power, asymmetric warfare, and innov

One of the greatest innovations in history, ENI Integrator and Computer–happened over sixty The world's first general purpose electronic co radical, incremental, and revolutionary innovat the computer and of the information transform first machine ever invented that amplified the strength.

Factors Influencing Innovation

Newton saw an apple fall, Einstein knew there of light experiments, and Mauchly wanted to p stock market. All had an idea. They nurtured it wondered about it, and went about solving the

There are a number of factors involved in inno environment of need (war, depression, epidem (industry, Babbage, Lister); and funding (gover support, both psychological and financial.

There is "passion": the guts and "fire in the bel a breakthrough with a revolutionary/disruptive fortitude. Bill Gates slept in a knee hole of a de garage with Steve Wozniak until the first show Bill Hewlett and David Packard built their devic moved into a factory and launched the Hewlet Company. John Mauchly bought used gas tub

soldered circuits, and built counters from 1936
Presper Eckert to join him in building a compu
funding until they won a government contract

There has to be an idea: disruptive (cell phone
incremental (wing design, FM, laptop, internet)
antibiotics, atomic energy, the computer, perso
nanotechnology).

Financing is needed. This often comes from th
DOD, CIA, Energy) for basic science, and was t
computer efforts. Government funding can be
bureaucratic. There is also corporate support,
profit-motivated, and also cautious, sometimes
oriented, often covering applied research. Aca
heavily on government support, along with ind
capitalist) support, which is success oriented, r
adventuresome, and has supported the major
fifty years (Microsoft, Apple, Oracle, Google, Ya

Of course, an innovation must have impact–it r
particular, a truly revolutionary innovation will b
new products, industries, and redirection to pe
doing things. It must be focused–buckshot oft
rifle in the hands of a marksman usually hits its
and energy is lost in the absence of focus

ENIAC

February 14, 1946, saw the first public demons
first such computer that worked, and it continu
almost ten years, finally ceasing operations on

ENIAC was the “wheel” of the new industrial re
wave of change, enterprise creation, and disru
significant change in the way we worked, play

organized ourselves. The computer revolution
industrial infrastructures, new giant companies
for many.

ENIAC not only paved the way for the develop
technology and information systems, but it pro
that initiative. Following this success strategy c
today.

ENIAC was the brainchild and work product of
scientists at the University of Pennsylvania. Th
the invention was Mauchly, a 38-year old profe
School of Electrical Engineering; Eckert was th
genius, who teamed with Mauchly as a 22-yea
spearhead the birth of the computer and inforr

One has to consider the nature of ENIAC in the
When the government contract to develop EN
concept behind it was contrary to the prevailin
U.S. MIT and Harvard were heavily involved in
“differential analyzers”, mechanical analog com
differential equations by integration, using whe
perform the integrations, and Dr. John Atanasc
was concerned with creating a special purpos
capable of solving systems of simultaneous ec
true general purpose digital electronic comput
beyond these efforts.

The idea of a machine to do calculations is not
“counting board” (later, “abacus”) was invented
Greeks invented a machine to plot the course
seventeenth century, Napier Bones developed
nineteenth century, Charles Babbage built me
Vannevar Bush at MIT began work on the diffe

Mauchly began thinking about calculating mac
time, and in 1935 he started tinkering with circ
1936 a brilliant mathematician at Cambridge U
a paper on how to solve numerical problems w
objective was to establish methodology for bre
pointed the way to building machines that cou
arithmetic procedures for solving complex pro
encrypted messages.

The British effort was heavily concerned with t
work proceeded with the building of ten Colos
operated at the British decoding facility at Blet
doubt that these machines were a significant f
German bombing offensive against Britain in 1
throughout World War II. But Turing never built
built a single circuit, nor did he design any. Wh
executed, the Colossus machines were specia
limited purpose–at which they were very effec
messages. There is a world of difference betw
machine and a general purpose computer. For
a special purpose machine used in drilling hol
whereas a lathe is a general purpose machine
making just about anything.

Atanasoff and Charles Berry began building th
Computer) in the late ’30s at the University of
a magnetic drum; ABC was a special purpose
simultaneous equations; it never completely w
up to 27 simultaneous equations in 27 unknow
was rebuilt in 1972; but a replica built in the 19
equations in two unknowns. ABC was single p
electronic, and was slower than a rotary calcul

Remember, Mauchly started building computin
Communication in the 1930s was not that of to
no instant messaging, and travel was difficult.

money. Mauchly bought used radio tubes to bu
money.

Hence the idea and desire for a computer was
solving that problem in a total system concept
designed it, and then found someone to build

ENIAC was an outgrowth of Mauchly's efforts a
in the 30s and his concept of a fully integrated
machine that could be applied to any type of n
pet peeve was to eliminate the need to reente
problem solution proceeded. The concept, des
was so directed. ENIAC succeeded. Mauchly c
student, Eckert, to join him in this effort in 1941
created the Information Age as we know it tod
vision; Eckert created the circuits to make it ha

As a young boy, Mauchly strove to understand
natural tinkerer, he took apart locks and studie
telephones. Climbing into a telephone compar
Chevy Chase, Maryland, he would hook up wir
room, and even fashioned an intercom system
bedtime, he furtively placed a sensor under th
alerting him of his parents' approach.

His interests were broad, he was good natured
man. But Mauchly was stubborn beyond all be
idea, he wrestled with it until he had it solved.
closely with him in the 1950s and early 1960s.
answer any question and examine any possibi
capability in his machines, totally general purp
conditional logic, and subroutines.

One story about Mauchly from his teaching da
wanted to demonstrate Newton's Third Law of
force has an opposite force that is set up–for e
cannon or rifle. John illustrated this law by wea

the desk in the front of the room. He threw a w
managed to keep from falling off the end of th
point.

Eckert was a methodical slave driver who swe
drive for perfection. His circuits had to be perf
meet all of Mauchly's visions, and more. While
the novel ideas in ENIAC, and later BINBAC an
was the prime mover in building the circuits ar
such as storage devices, printers, self-checkin
circuits–all common place today, but previousl
these capabilities. Eckert put all the pieces tog
and all within the plan and schedule he kept al
Eckert suffered fools badly.

An Opportunity

I asked Bill Mauchly, John's son, to comment o
how it could do any math problem 1000 times
what that means. It would be as if one day you
next day you could fly, anywhere, at 3000 mph
challenge–to be able to compute any problem

"*The*" problem, which was known to anyone w
computation in the '30s, was how to perform a
different operations on numbers very quickly. T
from hindsight, was straightforward: Use only e
moving parts in the mechanisms that *store* the
operations.

ENIAC worked at the electronic speed of 5000
could do this because the numbers were "stor
tape, rotating drums, or punch cards. The calcu
that speed, with no moving parts. And perhaps
operation could proceed immediately, without
human intervention; or branch logically. It took

urgent need, and government money to solve
machines of the time used slower storage: Col
paper tape and a bank of mechanical relays, w
magnetic drum that was regenerated with eac
are much slower than electronic memory.)

Bill Mauchly also commented on Philadelphia's
world–then and now. In the 1930s and 1940s t
often referred to as “tube alley” since so much
manufacture and design occurred in this regio
manufactured in the United States came from
were major forces in the field and in the count
manufactured overseas.

Taking these two major foundation stones into
Philadelphia the computer capital of the world
time it was.

After Mauchly and Eckert left the University of
the Electronic Control Company, and many of
worked on ENIAC joined them. They used born
and friends to get started, principally a $ 25,0
The team was enthusiastic, working long hours
reduced and occasionally completely deferred
bank or investment company was willing to ler
invest.

Eckert and Mauchly conceived of a true comm
which they termed and called UNIVAC–for UN
When they secured contracts with the Army, N
UNIVAC machines, they changed the name of
Mauchly Computer Company–EMCC , and sou
Mauchly was President–and salesman–and Ec
Chief Engineer. The objective of the company
market commercial computers. Despite their e
ability, this was very difficult for a start-up com

concerning fallacious concerns about military s
attitude of certain academic advisors to the mi
Mauchly's goals infinitely more difficult to achie
to build the first commercially available comple
electronic computer. The first UNIVAC was del
in 1951. Ultimately 46 UNIVAC I machines were
period ending in 1956. They were built in Phila

For a brief period, UNIVAC captured the major
electronic computer systems. These systems f
life averaging over nine years. The last machin
productive work as late as 1970 at Life and Ca
Census Bureau used its 1951 machine for twelv
for nine years. A UNIVAC was installed at the F
Philadelphia which I used in the mid and late 1
donated a UNIVAC to the University of Pennsy

Funding was always a problem for EMCC. Whe
the story was circulated that Tom Watson, Sr., t
IBM, did not foresee a large market for comput
story. Watson was concerned about antitrust a
problems if IBM were to acquire the Eckert Ma
subsequently Remington Rand bought the com
aggressive program of "catch-up" which ultima

Remington Rand bought EMCC in February of
negotiation that Mauchly ultimately accepted b
The net proceeds for inventing the computer f
Mauchly were $ 34,000 plus 25% of any future
and know-how. They ended up with 2.5%.

The computer industry in Philadelphia ultimate
late in making investments in the new industrie
shifted westward. Today the computer capital
Valley in California. Silicon Valley was a verdar
46 UNIVAC I machines were being built in Phil

that the term Silicon Valley began to appear in
silicon-based chip and computer companies su
others began to flourish in the area. Soon, Ste
his creation of Apple; and slightly to the north,
became the richest man in the world by licensi
technology was firmly in place.

Fostering Economic Growth by way of Innovat

Eckert and Mauchly created a revolution that p
the world–forward over the past sixty-three ye
women like them to once again bring us out of
bureaucratic think-inside-the-box attitudes hav

But we also need a highly focused system of s
of vision and drive to succeed. These people a
succeed, we must get back to the work of crea
system for innovation, while we still have time.

We may or may not be at war with an evil emp
1942, but regarding our standard of living, we l
hands and like Pogo, I believe that “we have s
us”.

As a nation we are at a crossroads. Our econo
world, is in a shambles. People are comparing
Great Depression of the 1930s. That is one vie
compare ourselves to the world that existed af
world economies were destroyed or nonexiste
ruins.

In the 1930s we attempted to spend our way o
packages were devised to put people back to
programs. Bureaucracies were created that kn
to solve the problem. The result was a continu
until World War II. While the message and rhet

were beacons of hope for the people, in reality policies of the administration did not complete economic growth to the country. Initiative was certainly not funded. The economy languished

World War II is distinct from our own situation. primary motivation then, not billions in set-aside stimulus package. If you're going to stimulate t stifle it with pay-back and pork-barrel politics. create success. The needs of warfare in 1941 s stultifying impact of the blanket of bureaucracy Innovation was sought, encouraged, and follow were enacted; lend-lease during the war, for ex Plan afterwards. The United States became the entirely new concepts of engineering and mar inefficient methods in shipbuilding, aircraft pro development. The concepts of operations rese idea that a team of people with different discip problems–and solve them. Radar, jets, antibiot born of this drive for innovation, investment, ar by dedicated teams of people without bureauc protected but often smothered. This solution c U.S. Army Ballistics Research Laboratory to inv calculate artillery trajectories. While this invest not produce a solution during the war, it did us innovation explosion, resulting in the greatest That innovation was the first general purpose ENIAC.

In World War II, victory at any cost was the prim the same kind of approach now. Business as u down the economic ladder.

Our current government must develop a conso Mauchly-type person to achieve his dream–to it is supported by the need to calculate artillery

The financial meltdown of the present is a barc
could bring. Success in countering this downtu
creating jobs, igniting the spark of American in
thinking. Let's look for an economic renaissanc

Notes:

[1] Wikipedia.org