

The spiritual essence of computer science

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I wish to sincerely thank all concerned for providing me the opportunity to share my thoughts with you today... and that includes my appreciation to each of you for being here.

My purpose this afternoon is to share with you a number of **personal reflections** on computer science and its relationship to matters of the spirit.

I am sure, as we reflect together today, you will gain some insight into what makes **me** tick,

but possibly also some new insights into our profession,

and possibly into yourselves.

To set a context for my remarks ...

I stand before you today

as a computer scientist

addressing a group of colleague computer scientists and
guests

to share some thoughts **about** computer science.

And no disrespect to other professions should be taken from the
fact that they will not be mentioned by me here today.

Let me begin with some rhetorical questions:

Do you believe that the decisions you make and the actions you take

can hurt you?
can help you?

Do you believe that the decisions you make and the actions you take

can hurt others?
can help others?

Do you believe that you have in your power,
to some extent,
the ability to shape the future?

your future?
the future
of your family?
of the people in this room today?
of this university?
of this country (or your country) or of the world?

Do you believe that you have in your power,
to some extent,
the ability
to make the future world a **worse** one?
or a **better** one?

Do you believe that the arena in which your decisions can make a difference ...

can extend

to the workplace?

and to computer science as a

discipline
and profession?

[pause]

The scope of modern computer science activity includes many technological dimensions, as we all know, including:

- computer hardware and software,
- communications hardware and software,
- interfaces with and between
 - computers,
 - other physical systems, and
 - human beings.

The scope of modern computer science activity includes many applicational dimensions as well, including:

- scientific applications,
- all kinds of commercial applications,
- military and defense...
- medical...
- educational...
- communications...
- entertainment...

In fact, there is hardly a sector of modern life that does not provide an opportunity for a computer application today.

Modern computer scientists have to have a working familiarity with all of these dimensions.

With respect to my remarks today, I encompass **all of these dimensions** when I refer to "computer science."

[pause]

With respect to the general technological activities of human beings,
I like to think of a five-level hierarchy of

rational empowerment

(meaning: empowerment that derives from the mental and intellectual activities of human beings, rather than from the physical).

Building up from the bottom, these five levels of rational empowerment are:

language,
communication and reasoning,
science,
engineering, and
politics.

[repeat]

language,
communication and reasoning,
science,
engineering, and
politics.

Of these five levels of rational empowerment,

language

serves as the foundation.

Language is the vehicle through which we express ideas...

for better understanding,

for retention, and

for communication ...

communication across both

space — between contemporary people, and

time — from one generation to a future one.

Language facilitates

correct thinking,

education,

teamwork,

effectiveness, and

efficiency

both personally, and
in society as a whole.

Language facilitates

the process of

conscious rational design

(which is what engineering, in its broad definition,
comprises).

The mastery of language is a prerequisite to seeking **truth** --

... for seeking truth, involves

the search for,

the discovering,

the recording, and

the sharing

of statements that accurately and precisely describe

how the world has behaved in the past,

how the world behaves today, and

how the world might be projected to behave in the future.

There are several forms of language, (as we know) ...

natural language (English for us in this room, today)

which can be

oral, and
written;

graphical language

which can be

informal, and
formal (such as: mechanical drawings, electronic
circuit schematics, charts and graphs);

mathematical language, in all its forms

(... arithmetic, geometry, trigonometry, algebra, integral
and differential calculus, logic, formal languages and
automata theory)

machine readable language

(which includes, but is not limited to our programming
languages like C and FORTRAN).

The serious computer scientist must aspire to be master of all
these.

The second level of rational empowerment is

communication and reasoning ...

that activity of human beings that builds on the foundation of language.

communication — the process of using language skillfully to record and share ideas and arguments both with oneself (over time) and with others (over both space and time), and

reasoning — the theory and methodology of analyzing and manipulating language statements to make valid deductions and plausible inferences.

The third level of rational empowerment is

science ...

that activity of human beings focused on

discovering,

understanding, and

describing

the world and how it seems to behave.

It builds on language and communication and reasoning.

The activity of science itself has several levels of maturity —

taxonomy — creating manmade definitions and categories to assist in organizing, simplifying, and abstracting one's thinking about a system;

kinetics — describing the behavior of a system as a time-function;

modeling — quantifying all possible (not just observed) interrelationships between all the boundary variables of a system

thus opening the door to a better understanding of the system through

mathematical analysis, and simulation.

The fourth level of rational empowerment is

engineering ...

(and here I mean engineering in its most general sense, not the narrow sense of, for example, civil engineering, mechanical engineering, or electrical engineering -- which are narrow legalistic notions of *professional and licensed* engineering)

Engineering is that activity of human beings in which one designs and creates a new entity (a material, an object, a mechanism, a process, ...) to effectively meet a need.

In an idealized view of the engineering process, one

identifies and clarifies a problem or need,

identifies a comprehensive set of alternative solutions,

evaluates the solutions and identifies optimal ones,

implements a solution(s),

effectively deploys the implementation,

maintains the implementation through its lifetime, and

manages the implementation's end-of-life.

Engineering is part science ... and part art.

As a participant in the engineering process one

deals with quantitative entities,

creates new design alternatives
(this is one of the intangible artistic components of
engineering),

pursues optimization goals, and

generally

educates,

convinces, and

leads

both oneself and others.

The fifth and highest level of rational empowerment is

politics (a higher, more difficult kind of engineering, really) ...

that activity of human beings in which one designs and creates a new entity to effectively meet a need

**and in the process of which
the cooperation of other people
is a prerequisite.**

This cooperation can be manifest as

consent
support, for example

	physical support	—	as provided by workers
	financial support	—	as provided by sponsors
	legal support	—	as provided by lawyers and government officials
and	emotional support	—	as provided by associates and loved ones.

The political process involves

decision-making,

followed by

effective action-taking...

[repeat] **effective** action-taking...

In many cases,
for really important engineering projects,
political success is a prerequisite to the tangible creative act.

Some observations:

Observation:

- ! When well done, activity at each level of rational empowerment can be quite difficult.

Observation:

- ! Granting this, I feel the levels can be ranked by their relative level of difficulty ... and also importance.

I would rank them from easiest to most difficult as follows:

1. (the least difficult) communication and reasoning,
2. science,
3. engineering,
4. language, and
5. (the most difficult) politics.

Observation:

- ! Anyone aspiring to fully implement an outstanding change in the **rational** world, will have to master the skills of politics.

Observation:

! Despite its name

computer science is not a science;

it is a special case **engineering** discipline.

It is an activity fundamentally focused on the design of new manmade systems intended to effectively and efficiently meet needs.

Computer science is the engineering profession focused on the technologies that address the

creation,

manipulations, and

uses of

data,

information, and

knowledge.

Computer science is a discipline at the forefront of an ongoing revolution in the world...

the information revolution.

As with predecessor revolutions associated with

agriculture,
energy,
industry
transportation, and
communication

computer science is (or should be — or could be)

a discipline that puts technology

in the service
of progress.

This means that it should be pursued in the context of a system of values ... which implies at least two different types of considerations:

First type of consideration:

What kind of goals are ethically and morally permissible?
[I do not intend to address this question in today's talk ...
but it is clearly an important question, and its proper
address requires use of disciplines in the humanities and
religion.]

and

a second type of consideration:

What kind of professional intensity and rigor should be exercised in the pursuit of chosen goals?

Computer science **DIFFERS** from most if not all other disciplines in engineering and science in that it is closely associated with one of the highest powers that human beings possess —

the power of the human INTELLECT.

Computer science focuses on

information and knowledge:

What is information and knowledge?

How do we characterize information and knowledge?

How do we organize it and represent it?

Computer science focuses on

information processing and transfer:

the design of effective hardware and software systems

that simulate or augment the intellectual processes
of **human beings**

and which include reliable information exchange
between machine and machine, and machine and
human beings.

Computer science **directly** augments or replaces the power of human beings to

know and remember,

communicate,

make decisions,

control physical and social entities,

and to enjoy.

Computer science enhances the intellectual power of human beings through the use of machines.

Now, knowledge is one of the sources of **POWER** to effect change ...

the power of man over the earth,
the power of man over life,
the power of man over other men.

Computer science, in dealing with systems and techniques that store, transmit, and manipulate knowledge, is a discipline related to **POWER**.

Computer science is the engineering discipline associated with machine-assisting mankind's striving for

rational empowerment...

...and from our days onward, computer science will be involved in enabling or augmenting all other engineering activities of the human race.

Computer science will provide the theories, the methodologies, and the implemented systems associated with the following grand progression:

1. specifying and implementing how information will be converted to machine readable data;
2. storing data, retrieving, transferring, and manipulating data in ways that are

 effective,
 reliable,
 efficient,
 secure, and
 which provide appropriate privacy protections;
3. analyzing information to discover new knowledge;

 thereby directly assisting human beings in the search for truth, and
4. participating indirectly **and directly** in making decisions... important decisions.

In certain cases, the decisions will be in the context of designing NEW SYSTEMS

-- the computer system acting as engineer.

Because of our understanding of the role our discipline
(and the systems we create through our discipline)
can play in the unfolding of creation

we should approach our discipline with great respect and with a
profound sense of responsibility.

We are not just "making a living."

We are being given an opportunity to be custodians of one of
the most precious powers in the world

— the power of knowledge and reasoning...

— the power of the mind

— the power that makes us **human beings** a special
partner in creation.

We have a duty to **prepare** ourselves for our profession
and to **conduct** ourselves within our professional lives

such that the systems we design and implement

perform with the highest level of integrity
that we are able to provide.

[pause]

Two weeks from now, I look forward to presenting some ideas along this **preparation theme** when I will present Part 2 of this colloquium on

"The **system** essence of computer science..."

It is a perspective that, in my opinion,

is not adequately developed

either in computer science practice today,

or in the curricula in which we prepare our students.

Computer science creates the working machinery
(both hard and soft)
that mankind has chosen to be an intellectual partner
in the pursuit of rational empowerment.

And just as a person is close to GOD

when he or she takes the GOD-given opportunity

to create in the world a new entity that did not exist
before,

so, too, our discipline is close to GOD

because it provides the machinery to assist

in the performance of these acts of creation

in a more rational way ...

[repeat]

so, too, our discipline is close to GOD

because it provides the machinery to assist

in the performance of these acts of creation

in a more rational way.

In closing, I acknowledge that I do not acquire very much of the truth solely by my own gifts and effort.

And so, with respect to the thoughts presented here today, I would like to recognize the help of a few special people ... among all those that have been my guides in life.

1. I owe a special debt to my parents and family (especially my father) for their belief in intellectual strength and honesty.
2. I owe much to my many teachers *and students*, both formal and informal, who have shown me much and shared with me in a unselfish way.
3. I owe much to my colleagues ... especially those I have known at

the IBM Corporation
The Thayer School of Engineering at Dartmouth College
Tuskegee Institute, and
Iowa State University

They showed me methods, attitudes, and benefits that come with true love of one's work and with cooperative collaborative endeavor.

4. I owe much to Myron Tribus, scientist, engineer, teacher, and mentor -- who showed me much about the joys and challenges of being a vital engineer **and** human being in the fullest sense.
5. And finally, I owe much to the Great Engineer and Teacher, who made us all, and who in His generosity allows us to share in the continuing creation that is His ... and ours.