Potential Harm of Introducing Advanced Computing Concepts in the Lower Years

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Anecdote #1

- **If your circuit simulator does not give the same answer as SPICE then your simulator is wrong.**
- **As a result, at least one commercial simulation package has two options:**

$\Rightarrow$ ‘‘give me the SPICE answer’’

$\Rightarrow$ ‘‘give me the right answer’’

Anecdote #2

- **At a recent conference on parallel processing a speaker said:**

  ‘‘There is no point in improving simulation package X. Engineers won’t use it anyway because they fear liability suits if they use anything but X.’’

Analogy #1

- **A common argument in favour of using simulation in teaching is that it gives the student an ‘‘intuitive’’ feel for the behaviour of the system.**
- **The counter argument is: Given a simulator for system X will a student eventually come to ‘‘understand’’ system X?**
- **Will the student rediscover the mathematics of the underlying system?**
- **What does it mean to ‘‘understand’’ a system?**

Analogy #2

- **Another argument for introducing simulation tools is to draw an analogy with the calculator.**

⇒ Should the calculator be allowed in the primary grades?

⇒ Given a calculator, will a student get an ‘‘intuitive’’ feel for addition? subtraction? multiplication? division? square root?

CEAB Curriculum Guidelines

- **Mathematics: min 1/2 year (includes computer programming)**
- **Basic Sciences: min 1/2 year**
  (‘‘analytical and/or experimental techniques used to impart understanding of natural phenomena’’)
- **Engineering Sciences and Engineering Design: min total 2 years, at least 1/2 year of each**
  (‘‘roots in mathematics and basic sciences ... creative applications ‘‘Appropriate content requiring the application of computers must be included...’
- **Complementary Studies: min 1/2 year**

General Reasons for Simulation

- **analytic tractability: ‘‘I don’t know how to analyze this.’’ OR ‘‘I know its not practical to analyze this’’**
- **cost: ‘‘Its cheaper to simulate than to prototype’’**
- **empirical studies: ‘‘What if?’’**

Anecdote #3

- **A colleague of mine reported that he did not allow calculators on a midterm last week. One of his students complained that it was too hard to add up a column of two digit numbers.**

$\Rightarrow$ Do advanced tools lead to loss of skill? (YES!)

$\Rightarrow$ Does loss of skill imply loss of understanding?

Anecdote #4

- **As technology advances, introductory microprocessor labs get more and more features.**

⇒ A lab computer can now have enough RAM/ROM to give it the ‘‘look and feel’’ of much more powerful systems.

- **Students no longer appreciate or understand how a computer really works:**

⇒ Typical questions:

- **‘‘Which instruction prints on the terminal?’’**
- **‘‘How do I create/read a file?’’**
  (this on a machine with no disk!)

Observation:

- **Students often construct incorrect models.**

IS SIMULATION A TOOL OR A CRUTCH?

- **If its a tool, then it is an intellectual lever.**
- **If we use it as a crutch, then we are intellectually lame.**

Anecdote #5

- **Students spend too much time writing lab reports.**
- **Students spend too much time writing computer programs.**
- **Students spend too much time doing X when they should be doing Y.**

Observation:

- **Students confuse activity with productivity.**

$\Rightarrow$ Computers (and simulation) tend to encourage activity.

Anecdote #6

- **Isaac Asimov wrote a story about a future in which the computer has become so pervasive that people don't know anything about arithmetic at all.**
- **Then, someone discovers that it is possible to compute with paper and pencil.**

$\Rightarrow$ This gave the person great power!

Observation:

- **Commercial success (market-place power) will come from understanding.**

Absurdity

- **Assume the simulation is so good that it exactly mimics the real world.**
- **Then do we ‘‘know’’ anything at all?**

$\Rightarrow$ The simulation forces the rediscovery of the fundamental laws...

$\Rightarrow$ Why not learn them in the first place?

The Role of Simulation in Undergraduate Engineering