The TeachScheme! Project

Adelphi University

Brown University

Northeastern University

University of Chicago

University of Utah

Worcester Polytechnic Institute

The Revolution

Two principles:

The Revolution

Two principles:

Shift away from machine details

The Revolution

Two principles:

Shift away from machine details

Emphasis on correctness over efficiency (ie, focus on program design)

What’s Wrong with Machine-Oriented Languages?

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machine arithmetic, pointers and memory addresses, even i/o

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- Force students to confront issues they are not prepared for

What’s Wrong with Machine-Oriented Languages?

machine arithmetic, pointers and memory addresses, even i/o

- Make students waste time on unimportant and uninteresting details
- Force students to confront issues they are not prepared for
- and ...

What Computer Science is *Not* About

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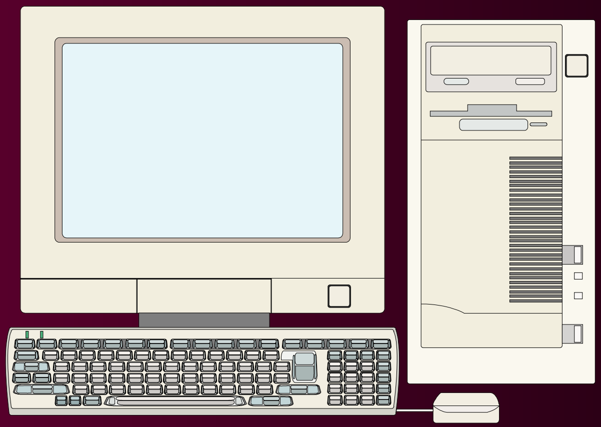


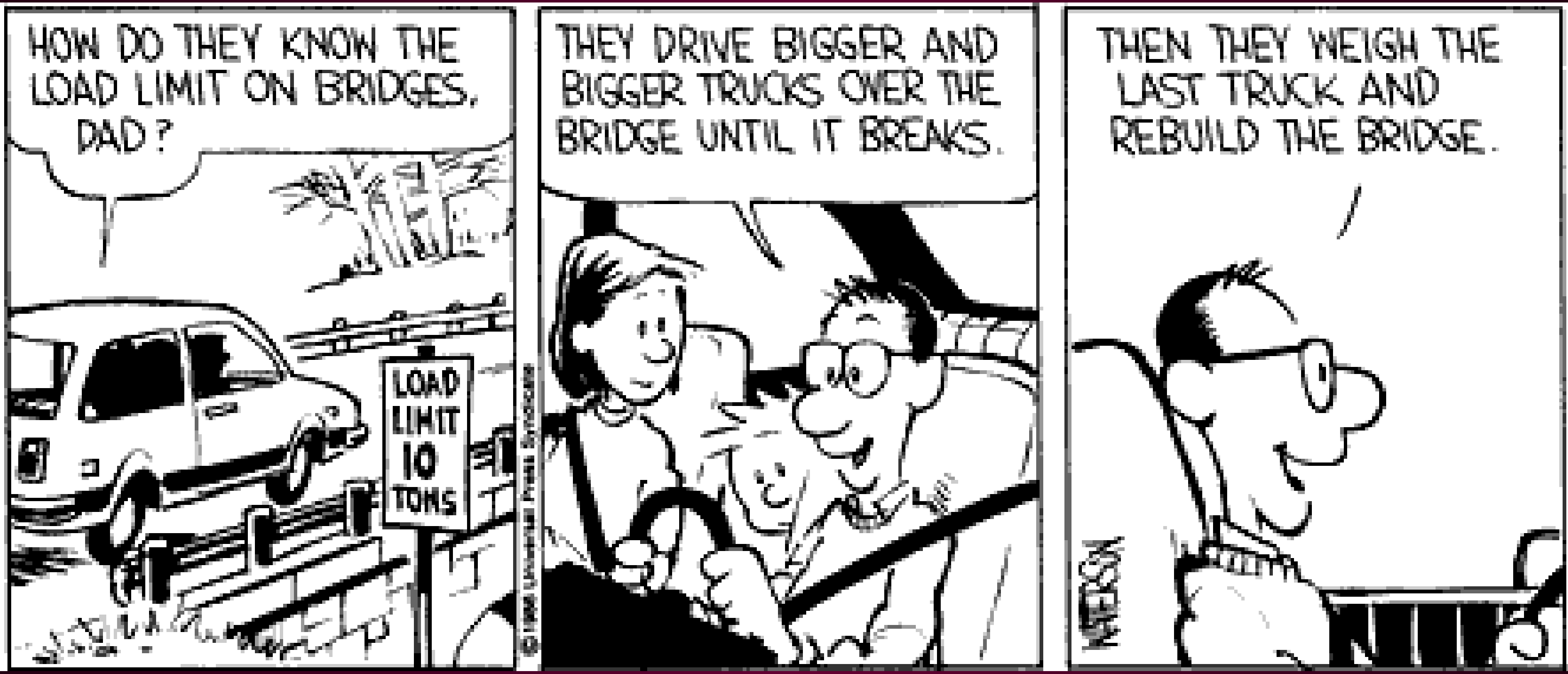
What Computer Science is *Not* About

What Computer Science is *Not* About

The computer!

Just as biology isn't "microscope science" and writing isn't "pen science" ...

What's This About Program Design?



Why Am I Here?

- The TeachScheme! Project: Outreach program hosted by six universities
- Specially designed for high schools
- Provides all material -- books, software, etc -- free of charge

What Teachers Experience

K.I.S.S.
Keep It Simple Syntactically

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Keep It Simple Syntactically

C++/Pascal

10% Problem-solving vs **<u>90% Syntax</u>**

K.I.S.S.
Keep It Simple Syntactically

C++/Pascal

10% Problem-solving vs **90% Syntax**

Scheme

90% Problem-solving vs 10% Syntax

The Golden Rule of Scheme Syntax

The Golden Rule of Scheme Syntax

(   )

The Golden Rule of Scheme Syntax

(Operation)

The Golden Rule of Scheme Syntax

(Operation List-of-Arguments)

The Golden Rule of Scheme Syntax

(Operation List-of-Arguments)

or

(Operation Arg_1)

The Golden Rule of Scheme Syntax

(Operation List-of-Arguments)

or

(Operation Arg_1 Arg_2)

The Golden Rule of Scheme Syntax

(Operation List-of-Arguments)

or

(Operation Arg_1 Arg_2 . . . Arg_n)

An Example From Arithmetic

4 + 5

An Example From Arithmetic

4 + 5

(Operation Arg_1 Arg_2)

Example #1 (cont'd)

4 + 5

(Operation Arg$_1$ Arg$_2$)

( )

Example #1 (cont'd)

4 + 5

(Operation Arg_1 Arg_2)

(+)

Example #1 (cont'd)

4 + 5

(Operation Arg_1 Arg_2)

(+ 4)

Example #1 (cont'd)

4 + 5

(Operation Arg$_1$ Arg$_2$)

(+ 4 5)

Example #1 (cont'd)

4 + 5

(+ 4 5)

Another Arithmetic Example

$$(4 + 5) \cdot 6$$

Example #2 (cont'd)

$$(4+5)\cdot 6$$

$$(\qquad\qquad\qquad\qquad)$$

Example #2 (cont'd)

$$(4+5)\cdot 6$$

(*   )

Example #2 (cont'd)

$(4 + 5) \cdot 6$

(* (+ 4 5)   )

Example #2 (cont'd)

$$(4 + 5) \cdot 6$$

(* (+ 4 5) 6)

Example #2 (cont'd)

$(4 + 5) \cdot 6$

(* (+ 4 5) 6)

An Example From Algebra

$4 + 5$

An Example From Algebra

$$4 + 5$$

$$f(x) = x + 5$$

Example #3 (cont'd)

$$f(x) = x + 5$$

(Operation $\quad$ Arg_1 $\quad$ Arg_2)

Example #3 (cont'd)

$$f(x) = x + 5$$

(Operation Arg$_1$ Arg$_2$)

(

)

Example #3 (cont'd)

$$f(x) = x + 5$$

(Operation Arg$_1$ Arg$_2$)

(define

)

Example #3 (cont'd)

$$f(x) = x + 5$$

(Operation Arg$_1$ Arg$_2$)

⇩

(function-name input-name)

⇩

(f x)

Example #3 (cont'd)

$$f(x) = x + 5$$

(Operation Arg_1 Arg_2)

(define (f x)

)

Example #3 (cont'd)

$$f(x) = x + 5$$

(Operation Arg$_1$ Arg$_2$)

⇩

(output-rule)

⇩

(+ x 5)

Example #3 (cont'd)

$$f(x) = x + 5$$

(Operation Arg$_1$ Arg$_2$)

```
( define ( f x )
    ( + x 5 ) )
```

Example #3 (cont'd)

$$f(x) = x + 5$$

```
( define ( f x )
    ( + x 5 ) )
```

Algebra vs Scheme vs Pascal

Algebra vs Scheme vs Pascal

Algebra

$$f(x) = x + 5$$

Algebra vs Scheme vs Pascal

Algebra

$$f(x) = x + 5$$

Scheme

```
( define ( f  x )
   ( + x  5 ) )
```

Algebra vs Scheme vs Pascal

Algebra

$f(x) = x + 5$

Scheme

```
( define ( f  x )
   ( + x  5 ) )
```

Pascal

```
Program  f  (Input, Output) ;
Var
   x :  Integer ;
Begin
   Readln ( x ) ;
   Writeln ( x + 5 )
End .
```

Design

D^3: Data Drive Design
(A Non-Numeric Example)

Consider program ***guest***, which determines whether a friend’s ***name*** is in a party’s invitation ***list***.

Is *Mathilde* In The List?

Is *Mathilde* In The List?

No

Is *Mathilde* In The List?

No

Mathilde

⋮

Is *Mathilde* In The List?

(empty)	**No**
Mathilde ⋮	**Yes**

Is *Mathilde* In The List?

No

Mathilde

⋮

Yes

John

⋮

Is *Mathilde* In The List?

List	Answer
(empty)	**No**
Mathilde ⋮	**Yes**
John ⋮	Look in the **Rest of the List**

Is *Mathilde* In The Rest of the List?

Is *Mathilde* In The Rest of the List?

No

Is *Mathilde* In The Rest of the List?

Mathilde ⋮

No

Is *Mathilde* In The Rest of the List?

	No
Mathilde ⋮	**Yes**

Is *Mathilde* In The Rest of the List?

	No
Mathilde ⋮	**Yes**
Sherry ⋮	

Is *Mathilde* In The Rest of the List?

	No
Mathilde ⋮	**Yes**
Sherry ⋮	Look in the **Rest of the List**

Pattern To Algebra

Algebra

guest (*name*, *list*) =

Algebra

$$guest(\ name,\ list\ ) = \left\{ \begin{array}{l} \\ \\ \end{array} \right.$$

Algebra

guest (*name*, *list*) =

{ if *list* is empty

Algebra

guest (*name*, *list*) =

no	if *list* is empty

Algebra

$$guest(\mathit{name}, \mathit{list}) = \begin{cases} \text{no} & \text{if } \mathit{list} \text{ is empty} \\ & \text{if } \mathit{name} = \text{first}(\mathit{list}) \\ & \end{cases}$$

Algebra

$$
\mathit{guest}(\mathit{name}, \mathit{list}) =
\begin{cases}
\text{no} & \text{if } \mathit{list} \text{ is empty} \\
\text{yes} & \text{if } \mathit{name} = \text{first}(\mathit{list})
\end{cases}
$$

Algebra

guest (*name*, *list*) =

no	if *list* is empty
yes	if *name* = first (*list*)
	otherwise

Algebra

$$guest(name, list) = \begin{cases} \text{no} & \text{if } list \text{ is empty} \\ \text{yes} & \text{if } name = \text{first}(list) \\ guest(name, \text{rest}(list)) & \text{otherwise} \end{cases}$$

Algebra

guest (*name*, *list*) =

Scheme

```
( define  ( guest  name  list )

                                                  )
```

Algebra

guest (*name*, *list*) =

$\begin{cases} \\ \\ \end{cases}$

Scheme

```
( define ( guest name list )



                                        )
```

Algebra

guest (*name*, *list*) =

{

Scheme

```
( define  ( guest  name  list )
    ( cond
                                              ))
```

Algebra

guest (*name*, *list*) =

{
- if *list* is empty
- if *name* = first (*list*)
- otherwise

Scheme

```
( define  ( guest  name  list )
   ( cond

                                  ))
```

Algebra

guest (*name*, *list*) =

if *list* is empty
if *name* = first (*list*)
otherwise

Scheme

```
( define  ( guest  name  list )
    ( cond
        (                                                              )
        (                                                              )
        (                                                              ) ))
```

Algebra

guest (*name*, *list*) =

if *list* is empty

if *name* = first (*list*)

otherwise

Scheme

```
( define  ( guest  name  list )
    ( cond
        ( ( empty?  list )                                        )
        ( ( equal?   name  ( first  list ))                       )
        (    else                                                 ) ))
```

Algebra

$$guest(name, list) = \begin{cases} \text{no} & \text{if } list \text{ is empty} \\ \text{yes} & \text{if } name = \text{first}(list) \\ guest(name, \text{rest}(list)) & \text{otherwise} \end{cases}$$

Scheme

```
( define  ( guest  name  list )
    ( cond
        ( ( empty?  list )                         'no                            )
        ( ( equal?   name  ( first  list ))        'yes                           )
        (    else                                  ( guest  name  ( rest  list ))  ) ))
```

Did You Notice?

Algebra

guest (*name*, *list*) =

no	if *list* is empty
yes	if *name* = first (*list*)
guest (*name*, rest (*list*))	otherwise

Scheme

```
( define ( guest  name  list )
    ( cond
        ( ( empty?  list )                   'no                          )
        ( ( equal?   name  ( first  list ))  'yes                         )
        (   else                             ( guest  name  ( rest  list ))   ) ))
```

Recursion Is Natural

Comparisons

Pascal

```
Program  NameOnList  (Input, Output) ;
Type
   ListType     = ^NodeType;
   NodeType   = Record
                     First :  String;
                     Rest :  ListType
                  End;
Var
   List      :  ListType;
   Name    : String;
Procedure GetList (Var List: ListType);  . . .
Function Guest (Name : String;  List    : ListType) :
String;
Begin
   If List = nil
      Then Guest := ‘no’
      Else If Name = List^.First
         Then Guest := ‘yes’
         Else Guest := Guest  ( Name, List^.Rest)
End;
Begin
   Readln ( Name );
   GetList ( List );
   Writeln (Guest ( Name, List ) )
End .
```

Pascal

```
Program  NameOnList  (Input, Output) ;
Type
   ListType      = ^NodeType;
   NodeType   = Record
                    First :  String;
                    Rest :  ListType
                  End;
Var
   List       :  ListType;
   Name     : String;
Procedure GetList (Var List: ListType);  . . .
Function Member (Name : String;  List    : ListType) :
String;
Begin
   If List = nil
      Then Member := 'no'
      Else If Name = List^.First
         Then Member := 'yes'
         Else Member := Member  ( Name, List^.Rest)
End;
Begin
   Readln ( Name );
   GetList ( List );
   Writeln (Member ( Name, List ) )
End .
```

Scheme

```
( define  ( guest  name  list )
   ( cond
      ( ( empty?  list                     `no                           )
      ( ( equal?   name  ( first  list ))   `yes                          )
      ( else                               ( guest  name  ( rest  list ))  ) ))
```

C or C++

```
#include <stdio.h>
typedef struct listCell * list;
struct listCell {
 int  first;
 list rest;
};
bool guest (int x, list l) {
 if (l == NULL)
  return false;
 else if (x == (l -> first))
  return true;
 else
  return guest (x, l -> rest);
}
int main (int argc, char ** argv) {
 list l1, l2, l3 = NULL;  int  x;
 l1 = (list) malloc (sizeof (struct listCell));
 l2 = (list) malloc (sizeof (struct listCell));
 l2 -> first = 3;  l2 -> rest = l3;
 l1 -> first = 2;  l1 -> rest = l2;
 scanf ("%d", &x);
 printf ("%d\n", member (x, l1));
}
```

Scheme

```
( define  ( guest  name  list )
   ( cond
      ( ( empty?  list                     `no                              )
      ( ( equal?   name  ( first  list ))   `yes                             )
      ( else                               ( guest  name  ( rest  list )) ) ))
```

Principles of Program Design

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- K.I.S.S.: Keep It Simple Syntactically

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- D^3: Data Drive Design

Principles of Program Design

- K.I.S.S.: Keep It Simple Syntactically
- D^3: Data Drive Design
- Recursion Is Natural

The Ping-Pong Game

9th Graders With

- Algebra I
- 12 Weeks of Scheme

Curriculum Comparison

- introduction
- syntax
- Turbo Pascal, i/o
- numbers, strings
- simple arithmetic
- text files
- conditionals
- procedures, stubs

Curriculum Comparison

- introduction
- syntax
- Turbo Pascal, i/o
- numbers, strings
- simple arithmetic
- text files
- conditionals
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- algebra, functions
- conditionals
- design recipes
- symbols
- linked lists
- structures, records
- graphics
- lists containing lists

The Programming Environment

Salient DrScheme features:

- interactive evaluation
- immediate error-reporting with source highlighting
- language presented as a sequence of increasingly complex layers

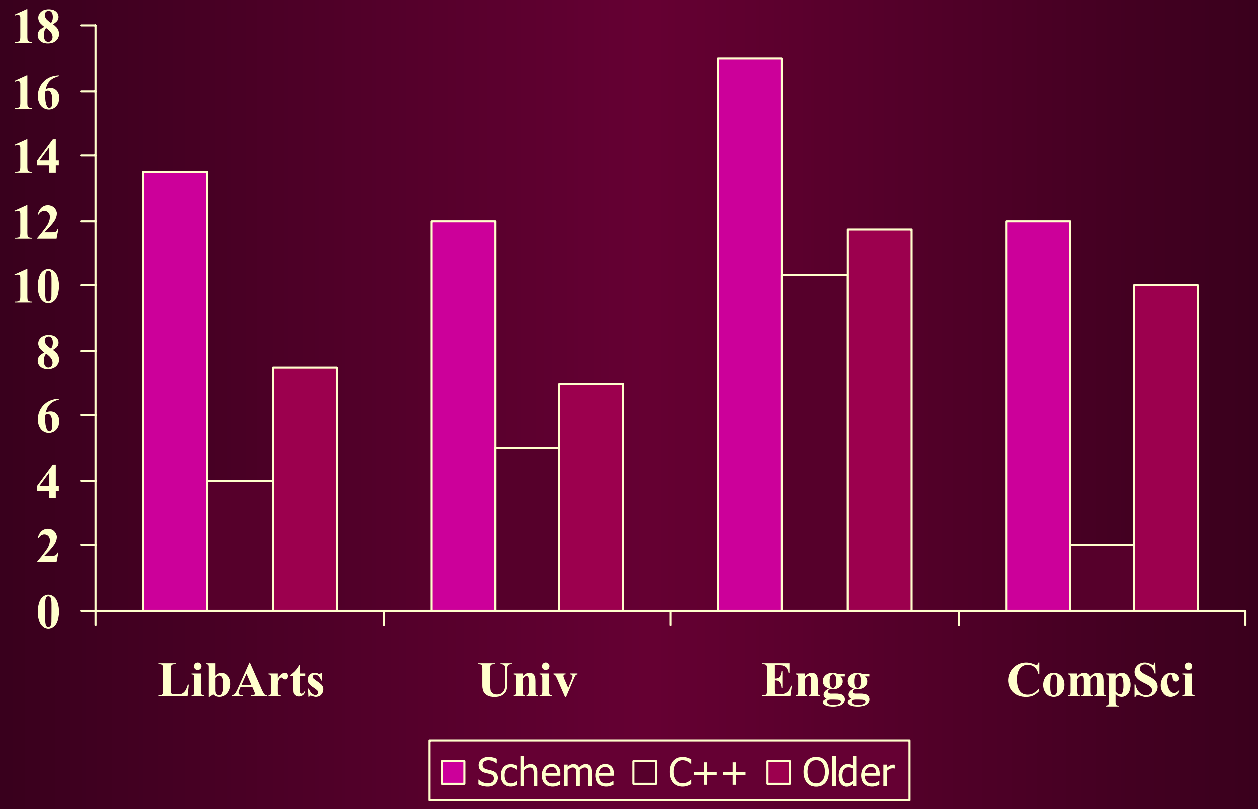
Putting it in Context

What a University Saw

Universities like Rice admit some of the best students in the nation; yet, the students cannot

- develop a program systematically
- separate problem solving from machine details
- explain why a program works (or doesn't)

What the ETS Wishes You Didn’t Know (~1998)



Conclusion

- Computer science education is undergoing a revolution
- TeachScheme! is at the forefront
- Schools and universities must collaborate to reap the benefits

What We Offer

- Textbook (*How to Design Programs*)
- DrScheme programming environment
- Teacher's guide
- Programming environment guide
- Exercises and solution sets
- Miscellany: help, summer course, etc

All available for free!

Web Information

See

http:/www.teach-scheme.org/

for information about the project, especially the free summer courses