Data Structures Discipline with Python

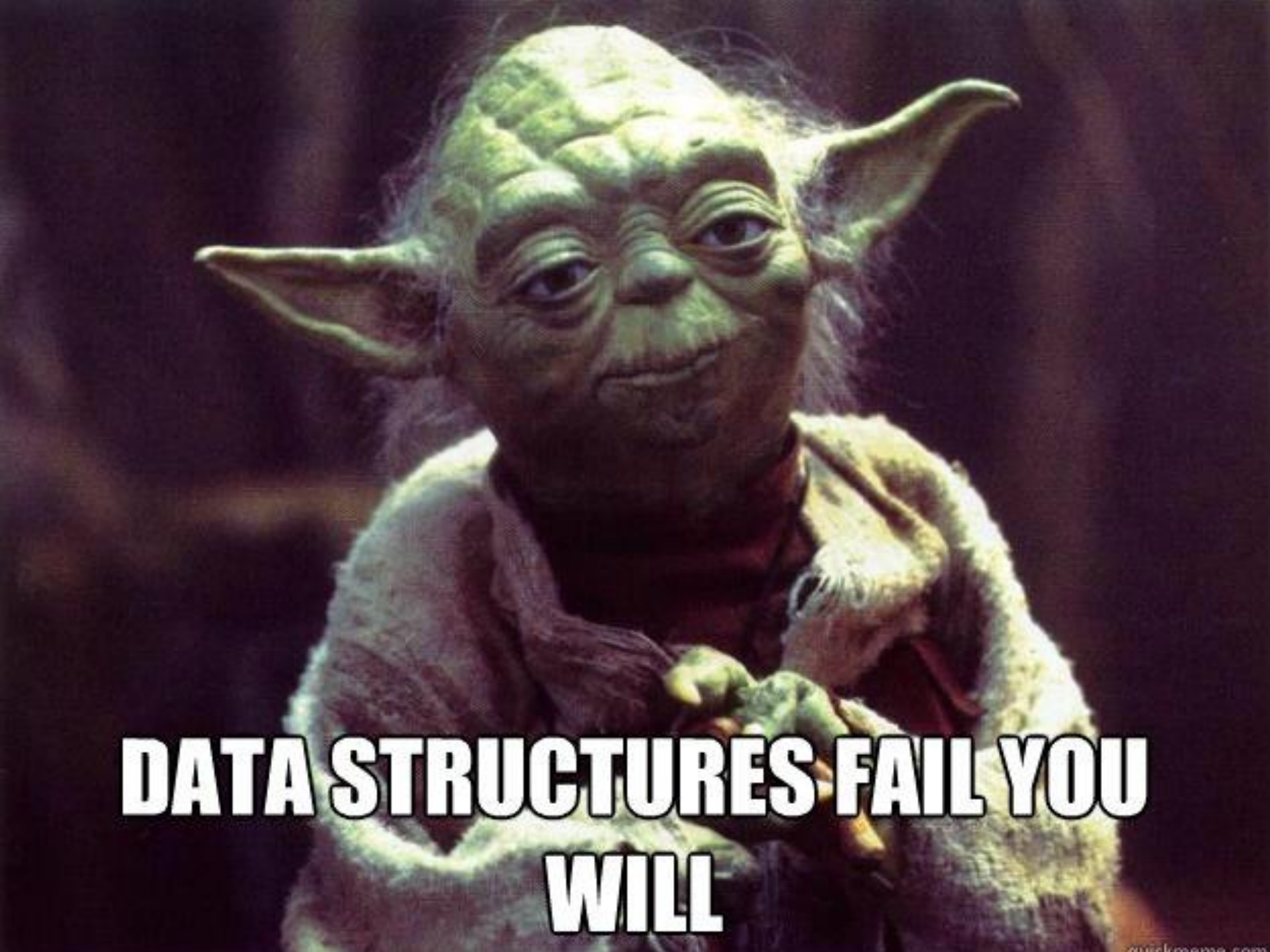
@fmasanori

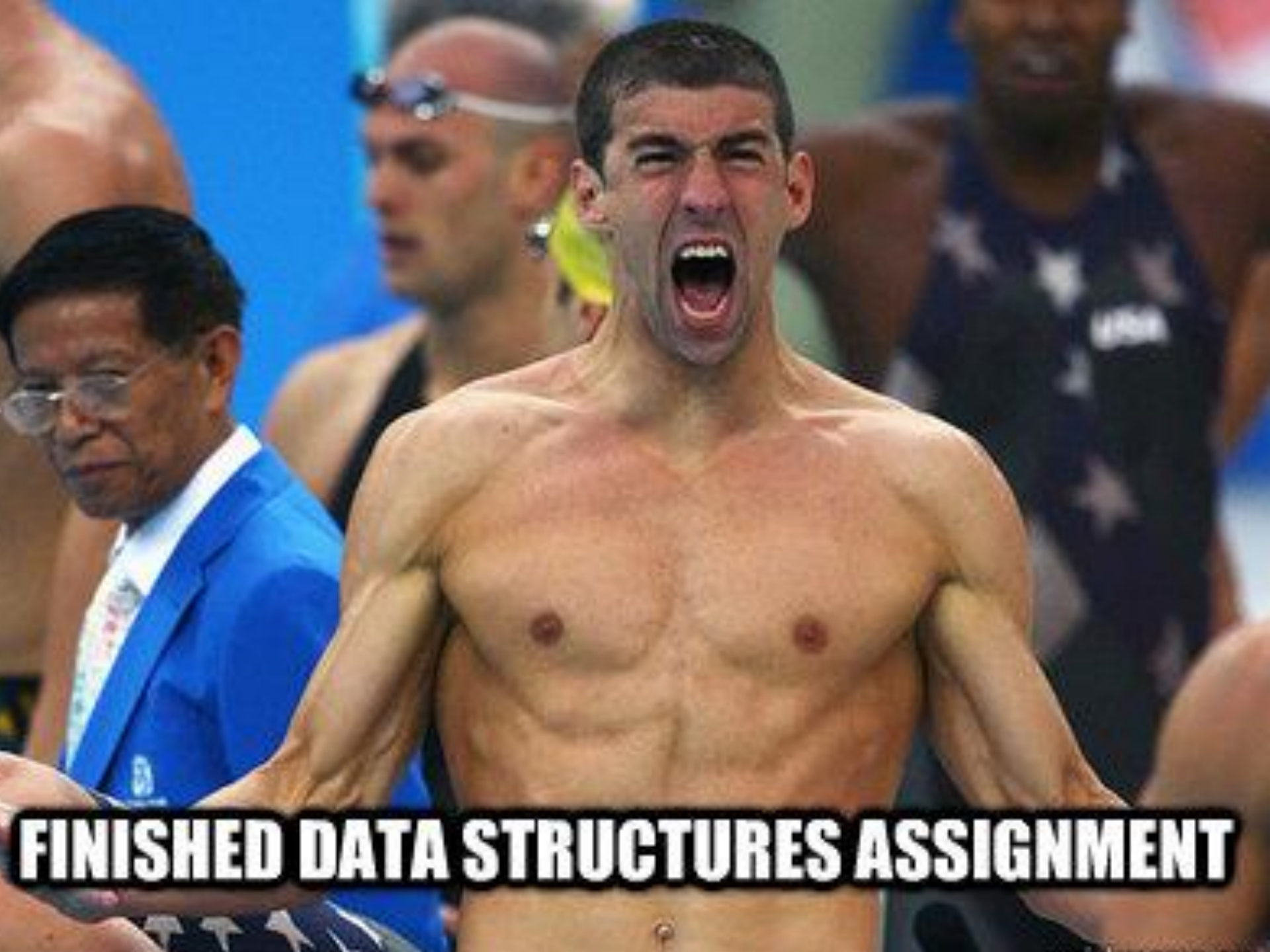
I love teaching

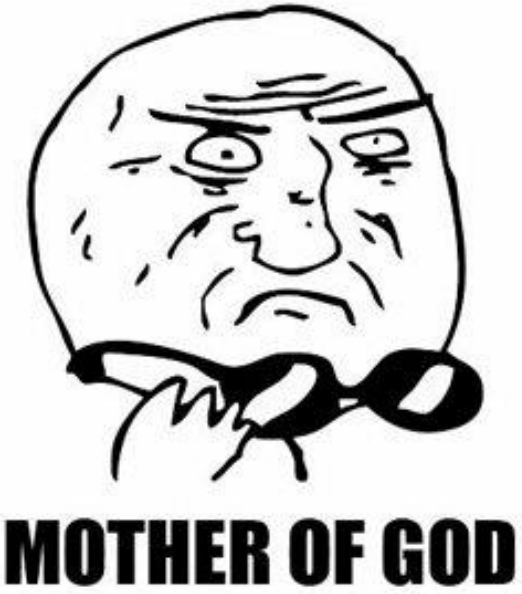
CS Professor at FATEC

https://about.me/fmasanori

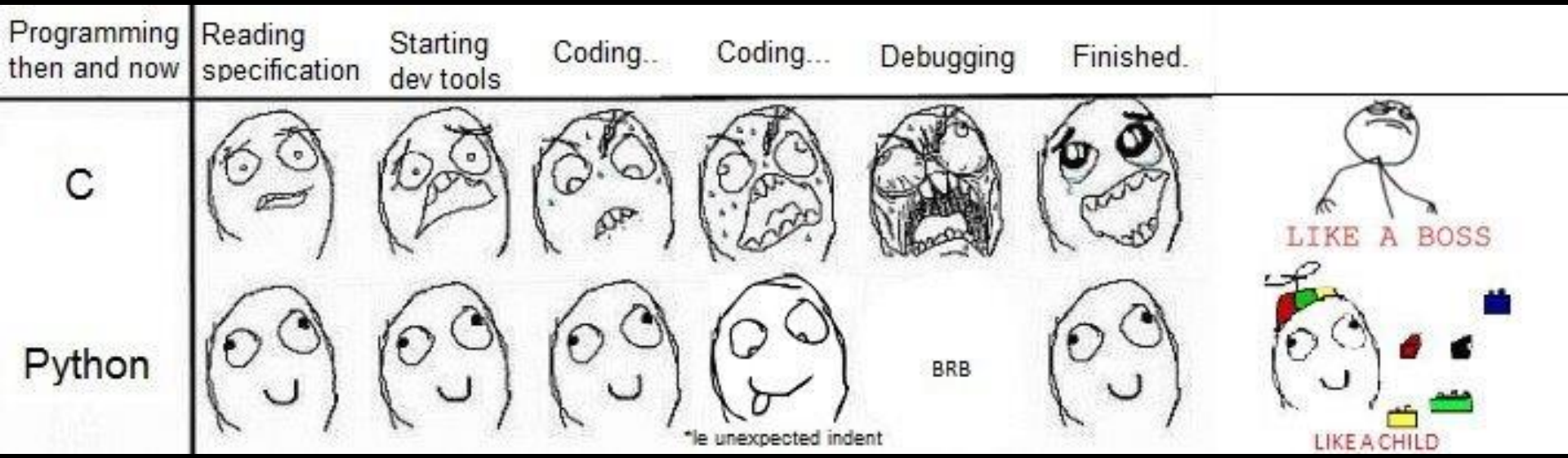
http://pycursos.com/python-para-zumbis/


DATA STRUCTURES FAIL YOU
WILL


FINISHED DATA STRUCTURES ASSIGNMENT



Difficult with C language

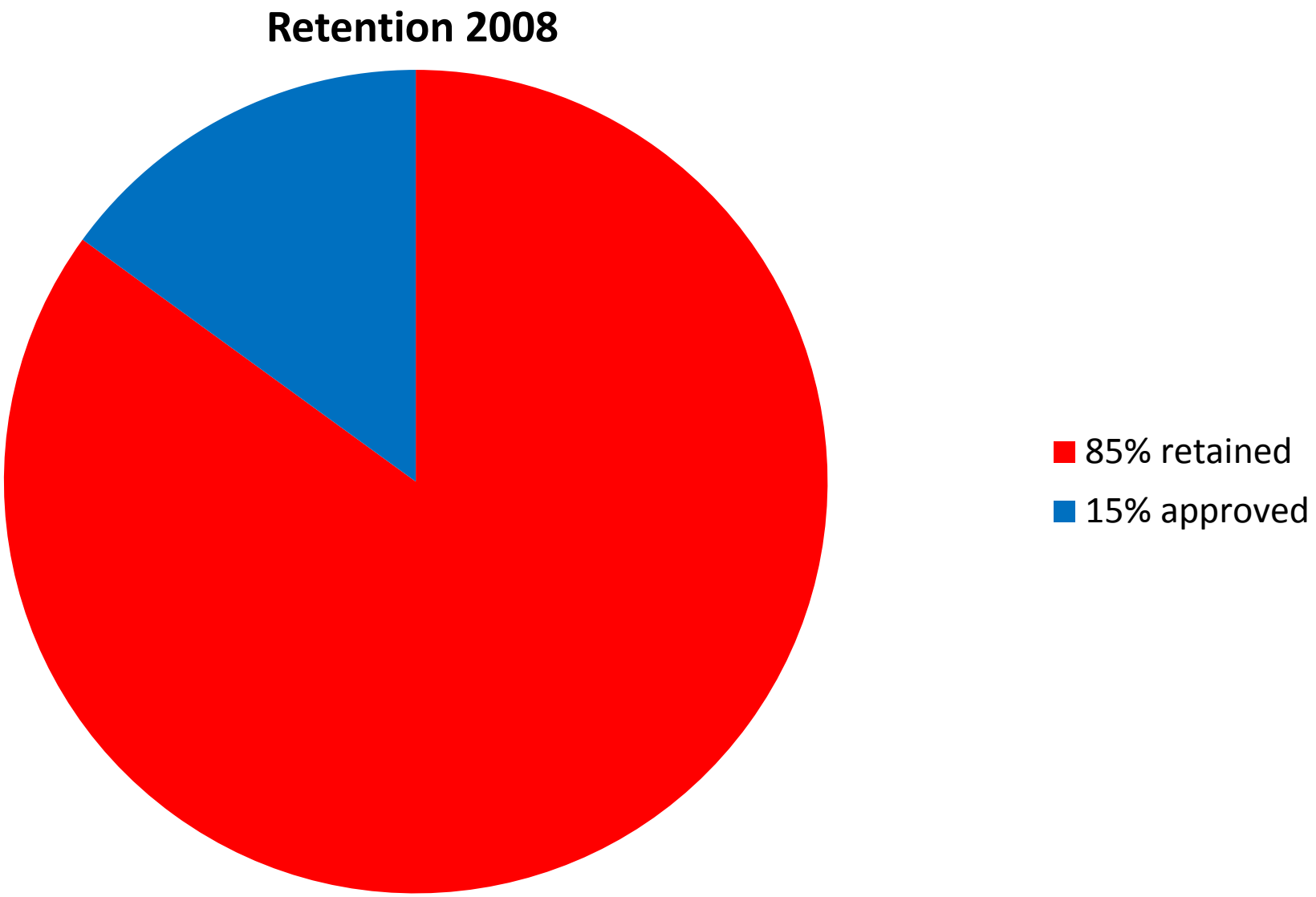


But I love Data Structures

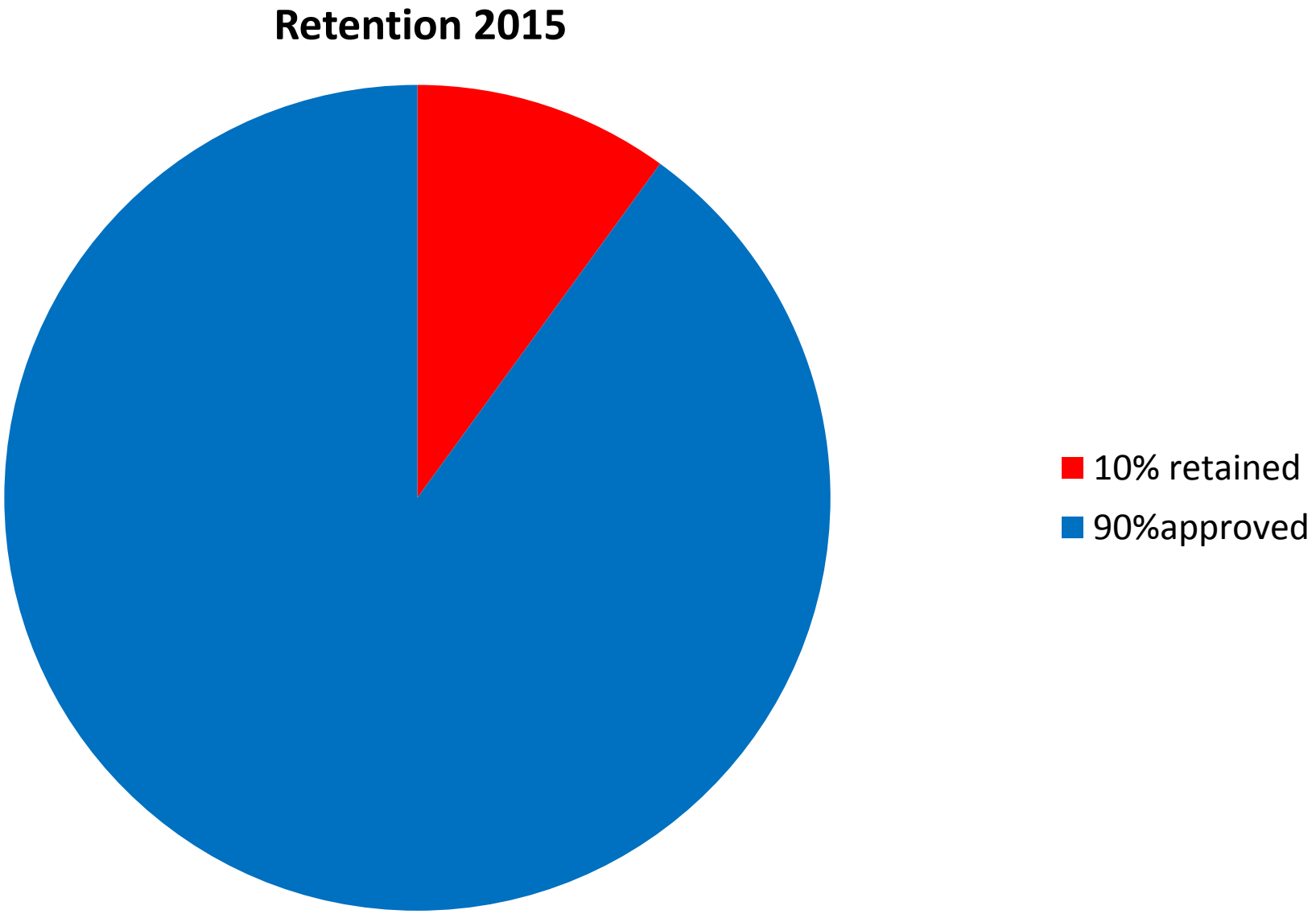
Data Structures are cool

Data Structures with Python at FATEC

Data Structures with C (2008)



Data Structures with Python (2015)



History

Data Structures with C:

- 85% retained (2008)
- First experiencies with Python (2011)

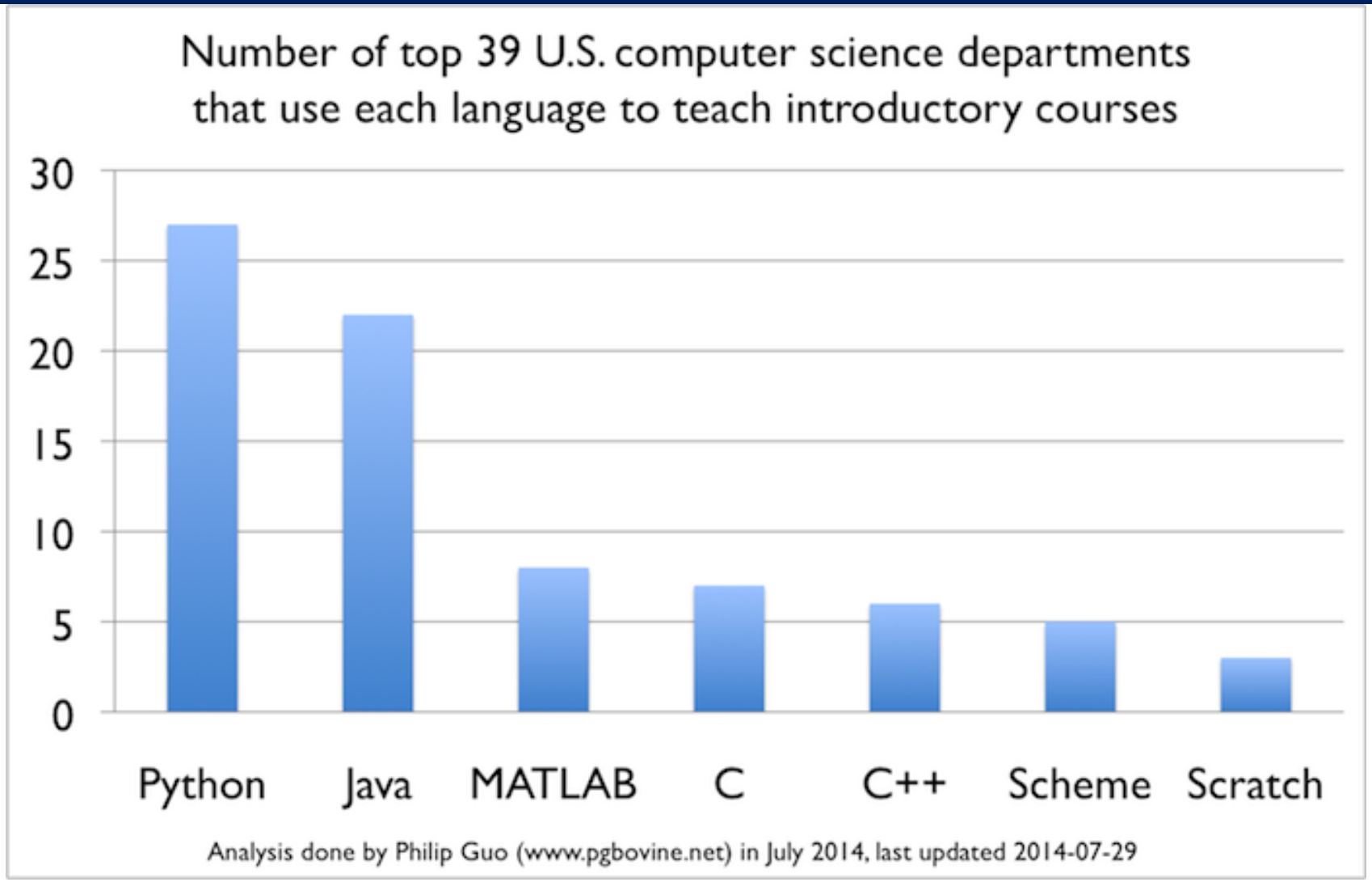
Python > C (2012)

- **10%** retained (2015)
- ENADE grade 5/5 (max) (2013)
- 1st Programming Contest InterFATECs (1st/62) (2014)

Details

- Lab Only – 4 classes/week
- 4 Lab Projects (Python)
- Big Brother (some of the best students could help the other students as coaches)
- Algorithms in C (few) and Python (mainly)

Why Python?



http://cacm.acm.org/blogs/blog-cacm/176450-python-is-now-the-most-popular-introductory-teaching-language-at-top-us-universities/fulltext

Usability is a problem for DS also...

"Results show that many aspects of traditional C-style syntax, while it has influenced a generation of programmers, exhibits problems in terms of usability for novices".

"Perl and Java did not accuracy rates significantly higher than a language with randomly generated keywords"

Andreas Stefik and Susanna Siebert: "An Empirical Investigation into Programming Language Syntax." ACM Transactions on Computing Education, 13(4), Nov. 2013.

The most common fault in computer classes is to emphasize the rules of specific programming languages, instead of to emphasize the algorithms that are being expressed in those languages. D. Knuth interview at People of ACM, June, 2014.

Talk is cheap.

Show me the code.

Linus Torvalds

Variables are just names (references)

```
>>> a = 42
>>> id(a)
1518584480
>>> id(42)
1518584480
>>> a = 'Python'
>>> id(a)
15542496
```

References == “pointers”

```
>>> a = [1, 2, 3]
>>> b = a
>>> id(a)
48767184
>>> id(b)
48767184
>>> a[0] = 42
>>> a
[42, 2, 3]
>>> b
[42, 2, 3]
```

```
>>> a = [4, 5, 6]
>>> b = list(a)
>>> id(a)
48772240
>>> id(b)
49151472
>>> a[0] = 42
>>> a
[42, 5, 6]
>>> b
[4, 5, 6]
```

Big integers

```
>>> 2 ** 1024
17976931348623159077293051907890247336179769789423065727343008115773267580550096313270847732240753602112011387987139335765878976881441662249284743063947412437776789342486548527630221960124609411945308295208500576883815068234246288147391311054082723716335051068458629823994724593847971630483535632962422413721 6
>>>
```

Natural integer division

```
>>> 1 / 2
0.5
```

```c
#include <stdio.h>

int main(void){
    printf ("%f\n", 1 / 2);
    system ("pause");
}
```

```
D:\Aulas\ED\divisao inteiros.exe
0.000000
Pressione qualquer tecla para continuar. . .
```

Multiple assignment

```
>>> a = 42
>>> b = 'avocado'
>>> a, b = b, a
>>> a
'avocado'
>>> b
42
>>> name, share, price, (year, month, day) = ['ACME', 50, 91.1,
(2015, 12, 21)]
>>> first, *middle, last = [-1, 1, 2, 3, 4, 5, -1]
>>> name, email, *fones = ('masanori', 'fmasanori@gmail.com', '
3923-3858', '8113-5934', '3905-4851')
```

Identation

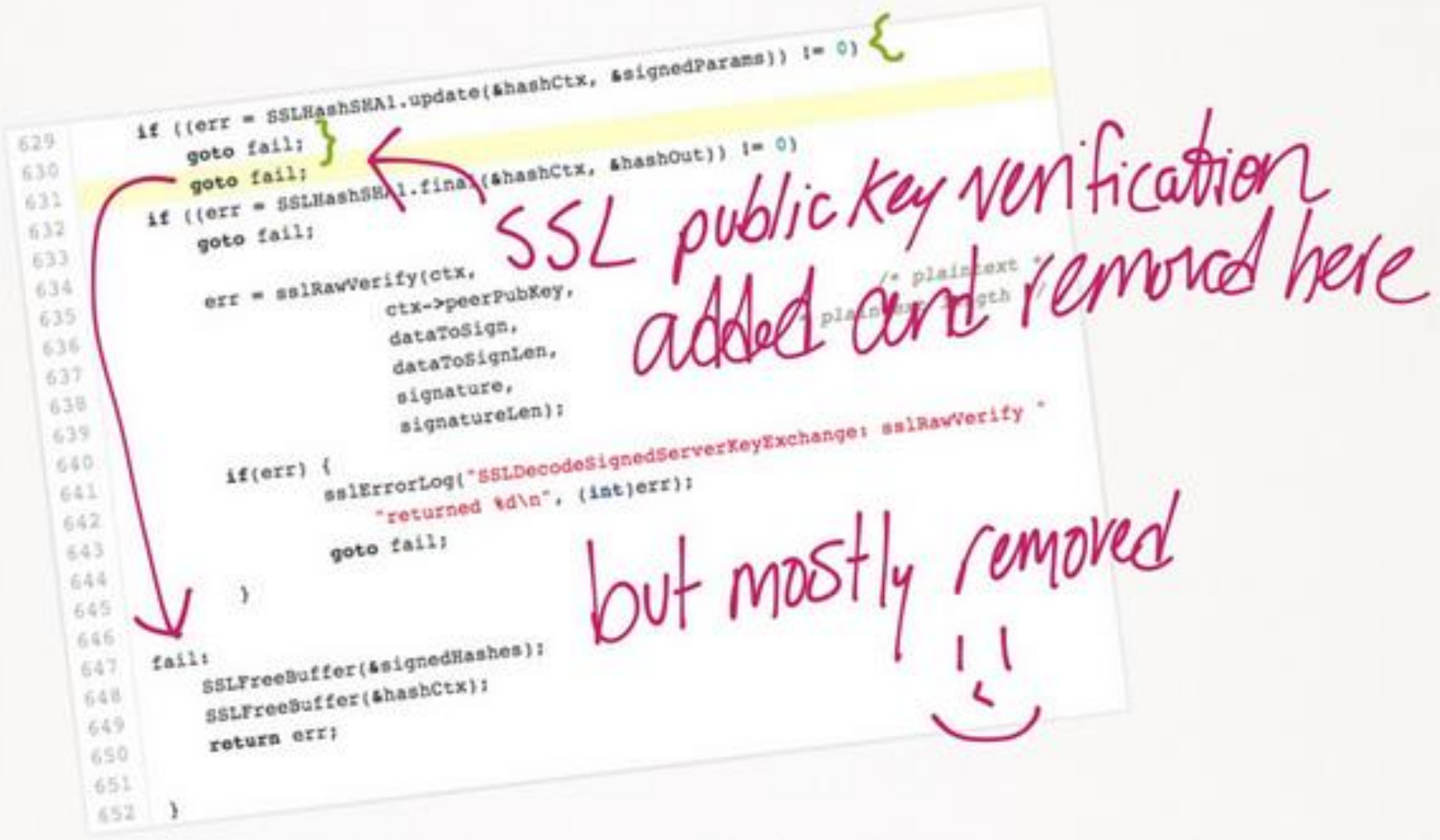
"The programming activity should be viewed as a process of creating works of literature, written to be read. “

--D.E. Knuth

Identation in C

```
1  for (i = 0; i < 10; i++);
2      printf("Dez vezes Hello World");
3
4  if (x < y)
5      if (pred(x))
6          printf("Um");
7  else if (x == y)
8          printf("Dois");
9  else
10         printf("Tres");
```

Identation in C



Recursion

"To understand recursion, one must first understand recursion."

--folklore

"To solve the problem, I found barriers within barriers. So, I adopted a recursive solution. "

--a student

Ref.: Feofiloff, P., Algoritmos em C, Editora Campus, 2009.

Recursion

```
def fib(n):
  print ('fib(%d)' %n)
  if n <= 2:
    return 1
  #bad O(2**n)
  return fib(n-1) + fib(n-2)

print (fib(5))
```

```
>>>
fib(5)
fib(4)
fib(3)
fib(2)
fib(1)
fib(2)
fib(3)
fib(2)
fib(1)
5
```

Recursion

```
fibcache = {}
def fib(n):
  if n <= 2:
    return 1
  if n in fibcache:
    return fibcache[n]
  fibcache[n] = fib(n-1) + fib(n-2)
  return fibcache[n]

print (fib(100))
>>>
354224848179261915075
```

Recursion

```
from functools import lru_cache
@lru_cache(maxsize=None)
def fib(n):
  if n <= 2:
    return 1
  else:
    return fib(n-1) + fib(n-2)

print (fib(100))
```

```
>>>
354224848179261915075
```

Recursion

```
def dec2bin(n):
  if n == 0:
    return ''

  return dec2bin(n//2) + str(n%2)

print (dec2bin(18))

>>>
10010
```

Linked Lists

```c
#include <stdio.h>
#include <stdlib.h>

struct cel {
        int cargo;
        struct cel *next;
};

typedef struct cel celula;

void Print (celula *lst) {
    celula *p;
    for (p = lst->next; p != NULL; p = p->next)
        printf ("%d\n", p->cargo);
}

```

Linked Lists

```
17  void Insert (int y, celula *p) {
18      celula *nova;
19      nova = malloc (sizeof (celula));
20      nova->cargo = y;
21      nova->next = p->next;
22      p->next = nova;
23  }
24
25  int main (void){
26      celula head;
27      celula *lst;
28      lst = &head;
29      head.next = NULL;
30      Insert (3, lst);
31      Insert (2, lst);
32      Insert (1, lst);
33      Print (lst);
34      system ("pause");
35  }
```

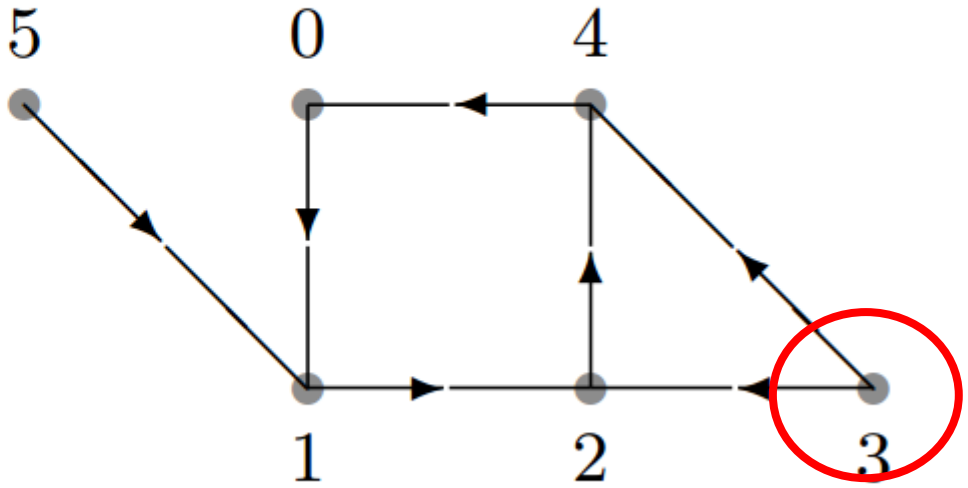
Linked Lists

```
class Node:
    def __init__(self, cargo=None, next=None):
        self.cargo = cargo
        self.next  = next
    def __str__(self):
        return str(self.cargo)
def print_list(node):
    while node is not None:
        print(node, end=" ")
        node = node.next
    print()

node1 = Node(1)
node2 = Node(2)
node3 = Node(3)
node1.next = node2
node2.next = node3
print_list(node1)
>>>
1 2 3
```

FIFOs: Distance in Networks

	0	1	2	3	4	5
0	0	1	0	0	0	0
1	0	0	1	0	0	0
2	0	0	0	0	1	0
3	0	0	1	0	1	0
4	1	0	0	0	0	0
5	0	1	0	0	0	0



	0	1	2	3	4	5
d	2	3	1	0	1	6

FIFOs: Distance in Networks

```
1  #define     TAM     6
2  int A[TAM][TAM] = {{0, 1, 0, 0, 0, 0},
3                     {0, 0, 1, 0, 0, 0},
4                     {0, 0, 0, 0, 1, 0},
5                     {0, 0, 1, 0, 1, 0},
6                     {1, 0, 0, 0, 0, 0},
7                     {0, 1, 0, 0, 0, 0}};
8  int *Distancias (int n, int o) {
9  int *d, x, y;
10 int *f, s, t;
11     d = malloc (n * sizeof (int));
12     for (x = 0; x < n; x++) d[x] = -1;
13     d[o] = 0;
14     f = malloc (n * sizeof (int));
15     s = 0; t = 1; f[s] = o;
16     while (s < t) {
17         x = f[s++];
18         for (y = 0; y < n; y++)
19             if (A[x][y] == 1 && d[y] == -1) {
20                 d[y] = d[x] + 1;
21                 f[t++] = y;
22             }
23     }
24     free (f);
25     return d;
26 }
```

FIFOs: Distance in Networks

```
A = [[0, 1, 0, 0, 0, 0],
     [0, 0, 1, 0, 0, 0],
     [0, 0, 0, 0, 1, 0],
     [0, 0, 1, 0, 1, 0],
     [1, 0, 0, 0, 0, 0],
     [0, 1, 0, 0, 0, 0]]

def Distancias(n, origem):
  d = [-1] * n
  d[origem] = 0
  f = []
  f.append(origem)
  while len(f) > 0:
    x = f[0]
    del f[0]
    for y in range(n):
      if A[x][y] == 1 and d[y] == -1:
        d[y] = d[x] + 1
        f.append(y)
  return d
```

Stacks: well-formed expression

```c
int BemFormada (char s[]) {
    char *p; int t;
    int n, i;
    n = strlen (s);
    p = malloc (n * sizeof (char));
    t = 0;
    for (i = 0; s[i] != '\0'; i++) {
    /* p[0..t-1] é uma pilha */
        switch (s[i]) {
            case ')': if (t != 0 && p[t-1] == '(') --t;
                      else return 0;
                      break;
            case '}': if (t != 0 && p[t-1] == '{') --t;
                      else return 0;
                      break;
            default: p[t++] = s[i];
        }
    }
    free (p);
    return t == 0;
}

int main (void) {
    printf ("%s\n", BemFormada ("(){(){}}") ? "Bem formada" : "Mal formada");
    printf ("%s\n", BemFormada ("({)}") ? "Bem formada" : "Mal formada");
    system ("pause");
}
```

Stacks: well-formed expression

```
def BemFormada(s):
  p = []
  for c in s:
    if c == ')':
      if p[-1] == '(':
        p.pop()
      else:
        return False
    elif c == '}':
      if p[-1] == '{':
        p.pop()
      else:
        return False
    else:
      p.append(c)
  return True

print (BemFormada('(){()})'))
print (BemFormada('({)}'))
```

Selection Sort

```
1  void Selecao (int n, int v[]) {
2      int i, j, k, min, x;
3      for (i = i < n-1; i++) {
4          min = i;
5          for (j = i+1; j < n; j++)
6              if (v[j] < v[min])
7                  min = j;
8          x = v[i];
9          v[i] = v[min];
10         v[min] = x;
11     }
12 }
13 int main(void){
14     int i;
15     int v[10]={7, 4, 3, 9, 0, 8, 5, 2, 6, 1};
16     Selecao (10, v);
17     for (i = 0; i < 10; i++)
18       printf ("%d", v[i]);
19     putchar('\n');
```

Selection Sort

```
def selection(v):
  resp = []
  while v:
    m = min(v)
    resp.append(m)
    v.remove(m)
  return resp

import random
v = list(range(10))
random.shuffle(v)
v = selection(v)
print (v)
```

Quicksort

```
1  int Divide (int p, int r, int v[]) {
2      int c, j, k, t;
3      c = v[r]; j = p;
4      for (k = p; k < r; k++)
5          if (v[k] <= c) {
6              t = v[j], v[j] = v[k], v[k] = t;
7              j++;
8          }
9      v[r] = v[j], v[j] = c;
10     return j;
11 }
12 void Quicksort (int p, int r, int v[]) {
13     int j;
14     if (p < r) {
15         j = Divide (p, r, v);
16         Quicksort (p, j - 1, v);
17         Quicksort (j + 1, r, v);
18     }
19 }
```

Quicksort

```
def quicksort(v):
    if len(v) <= 1:
        return v

    pivot = v[0]
    equals  = [x for x in v if x == pivot]
    smaller = [x for x in v if x <  pivot]
    higher = [x for x in v if x >  pivot]
    return quicksort(smaller) + equals + quicksort(higher)

print (quicksort([5, 7, 9, 3, 4, 0, 2, 1, 6, 8]))
```

Conclusions

- C is good for optimization (details, low level)
- Python is good to show the essence of the algorithms (clarity, high level)
- If the algorithm is the same (complexity) “premature optimization is evil” also in teaching Data Structures.

Questions?

gist.github.com/fmasanori

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Slides: bit.ly/python-DS