Data Structures Discipline with Python

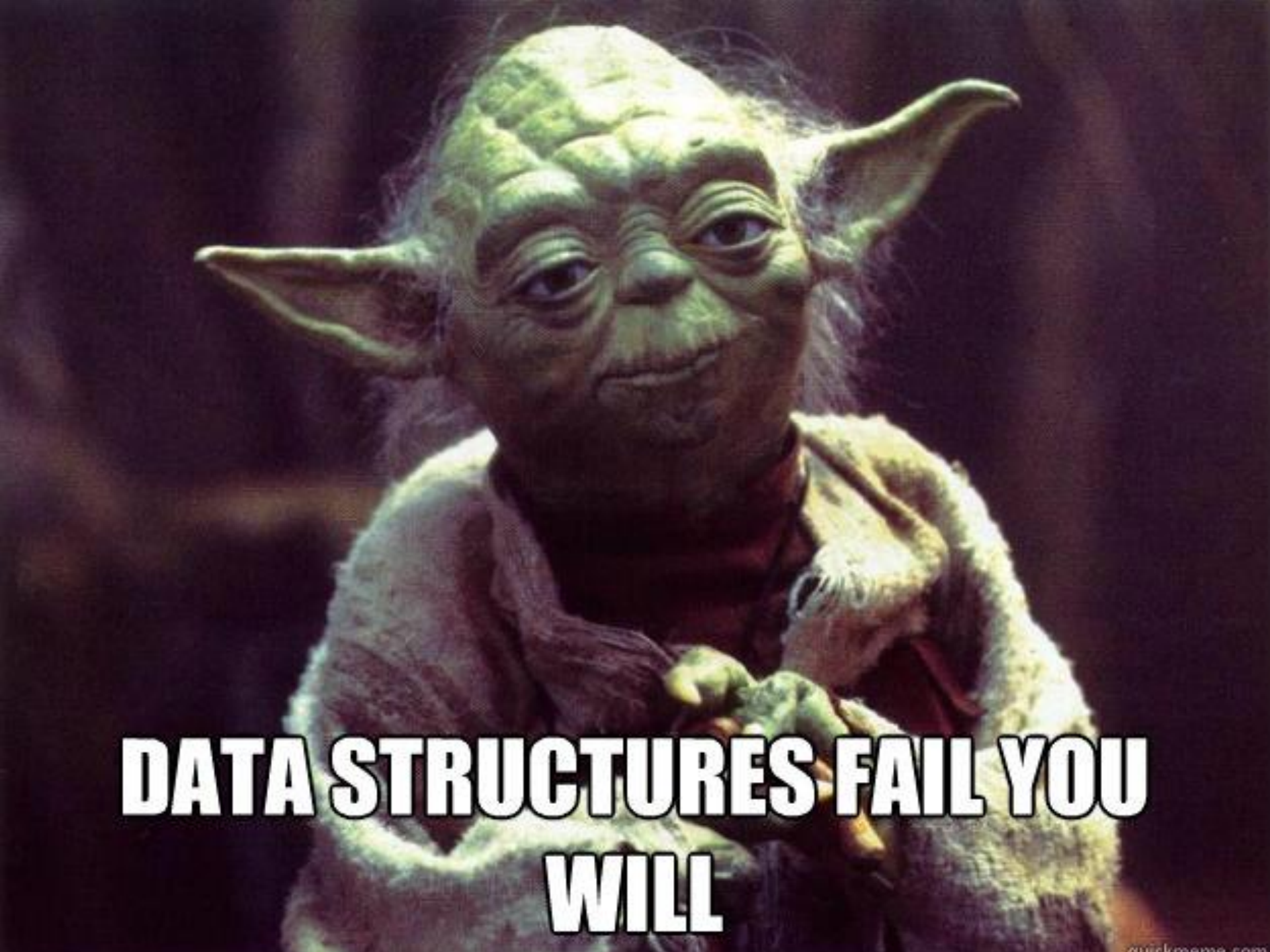
@fmasanori

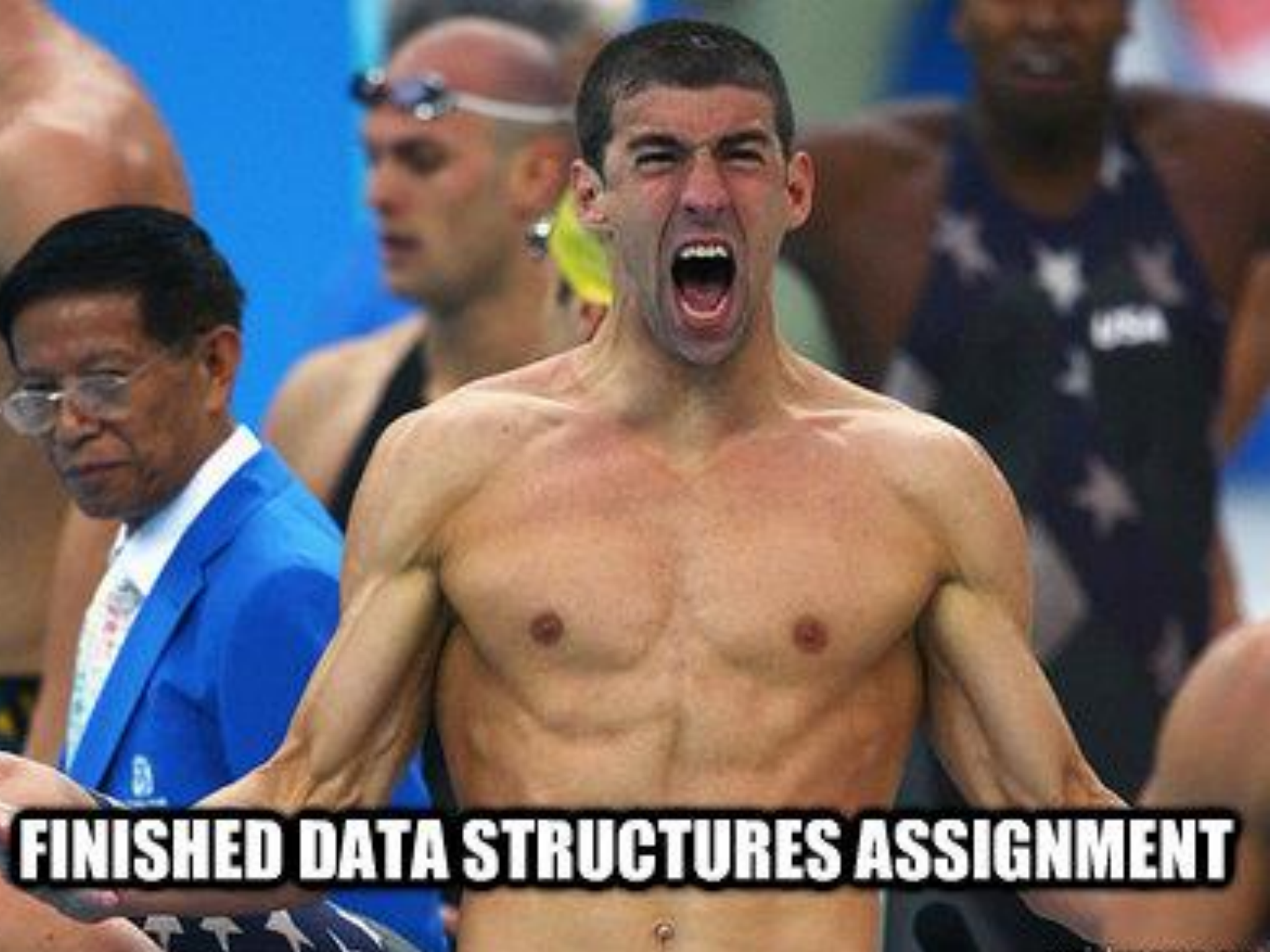
I love teaching

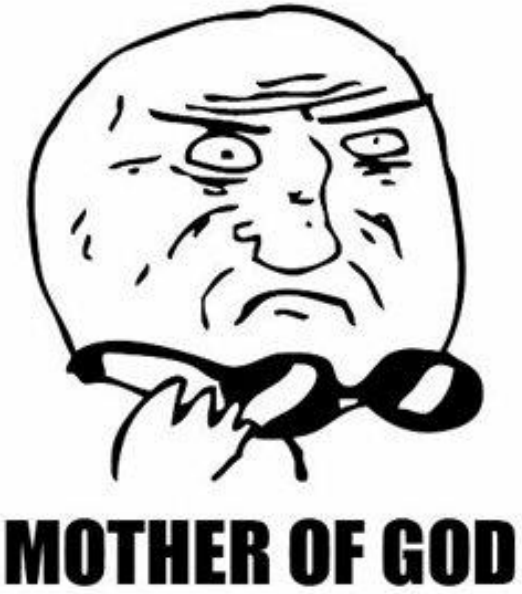
CS Professor at FATEC

https://about.me/fmasanori

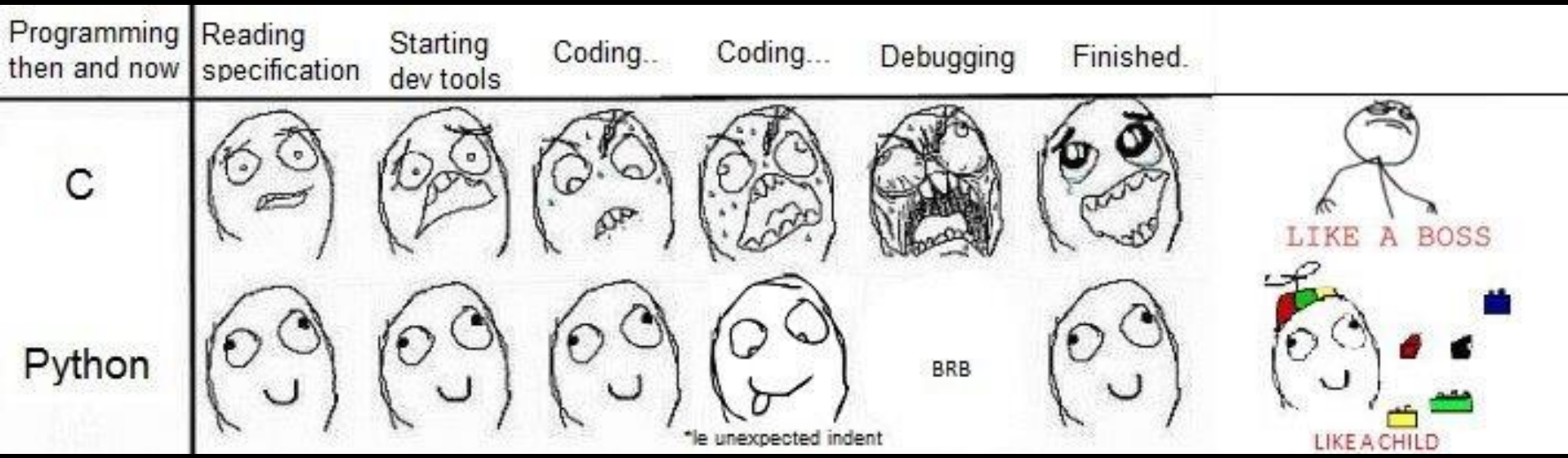
http://pycursos.com/python-para-zumbis/


DATA STRUCTURES FAIL YOU
WILL


FINISHED DATA STRUCTURES ASSIGNMENT



Difficult with C language



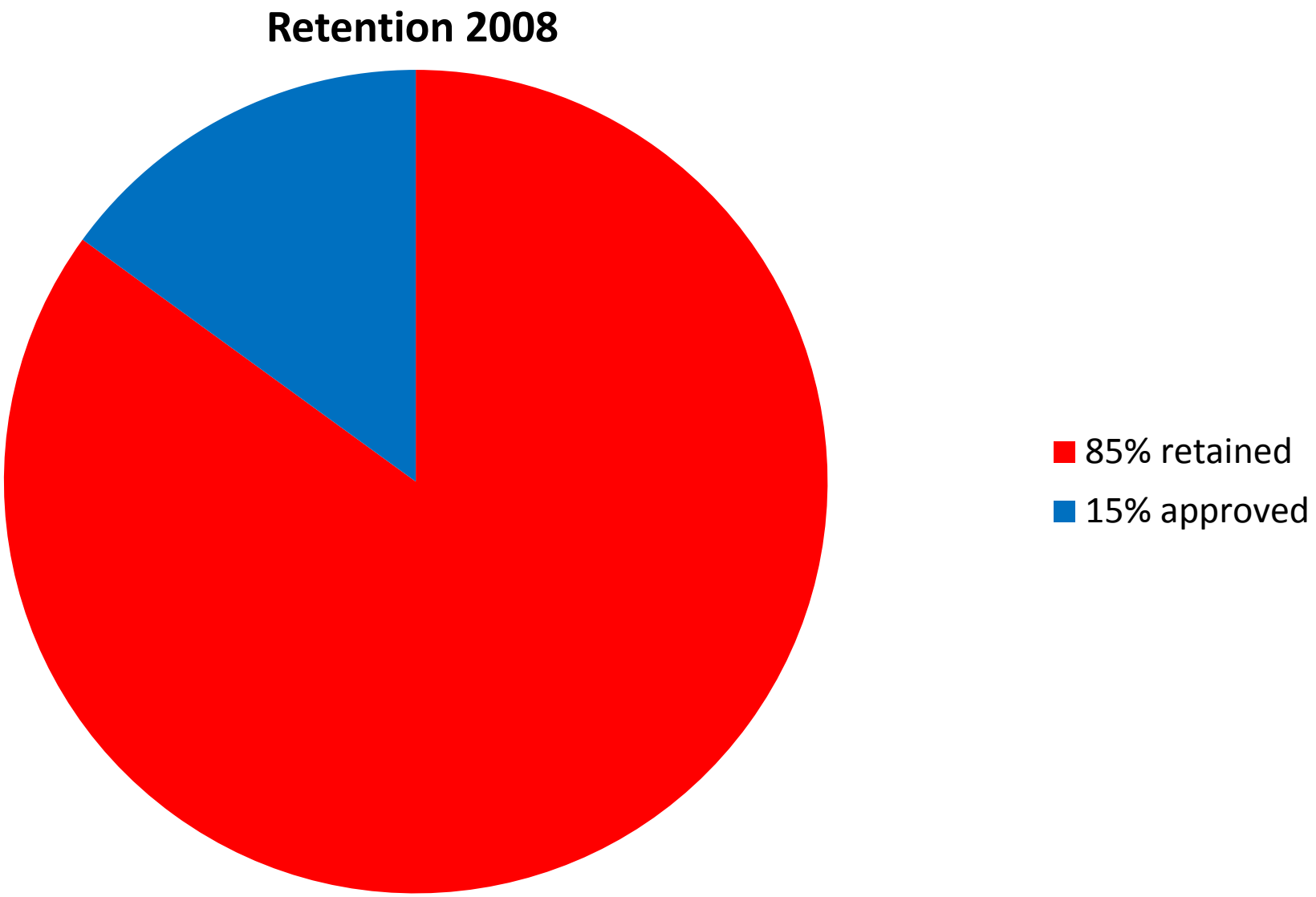
"A C program is like a fast dance on a newly waxed dance floor by people carrying razors."
Waldi Ravens. Programmer.

But I love Data Structures

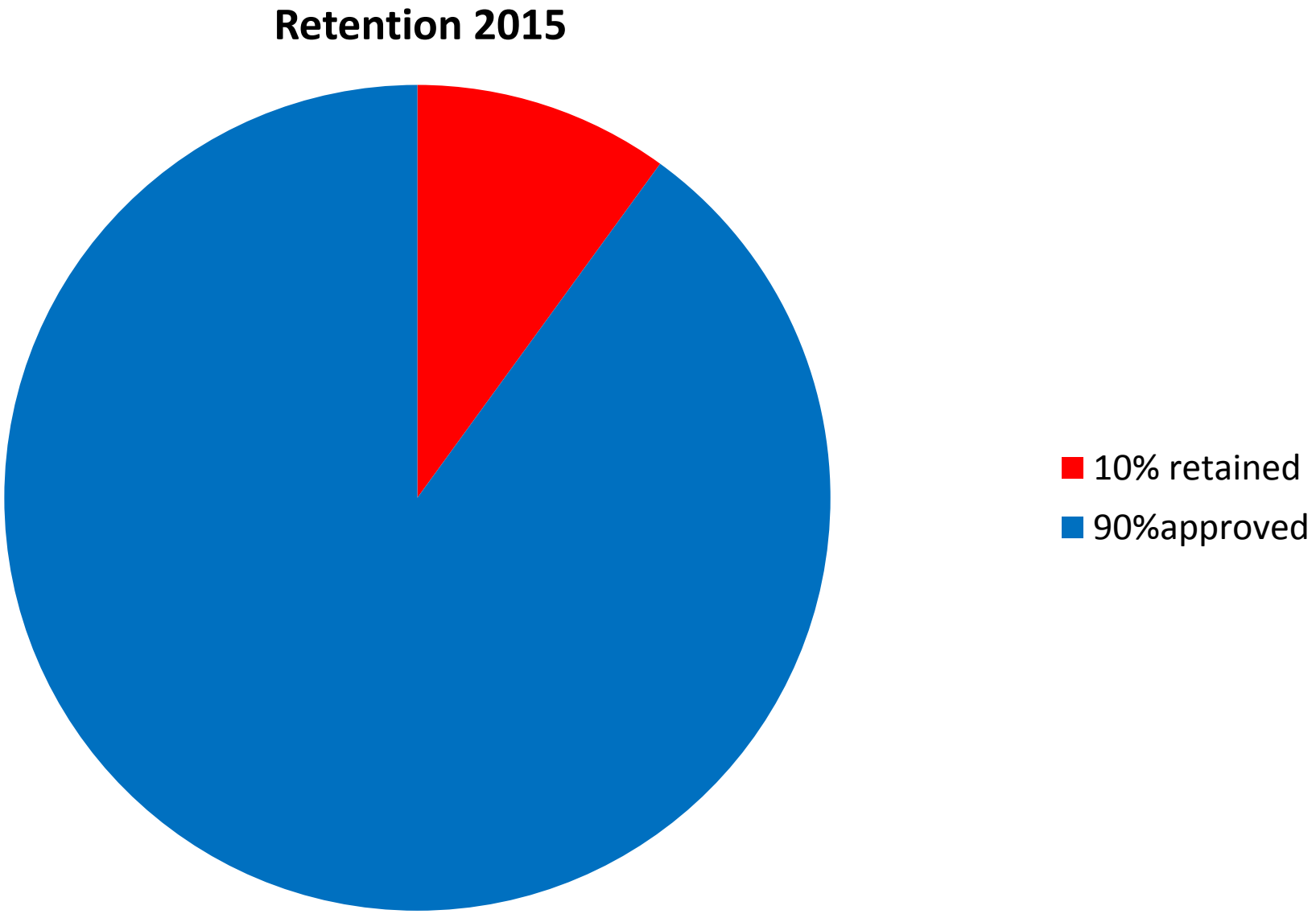
Data Structures are cool

Data Structures with Python at FATEC

Data Structures with C (2008)



Data Structures with Python (2015)



Summary

Data Structures with C:

- 85% retained (2008)

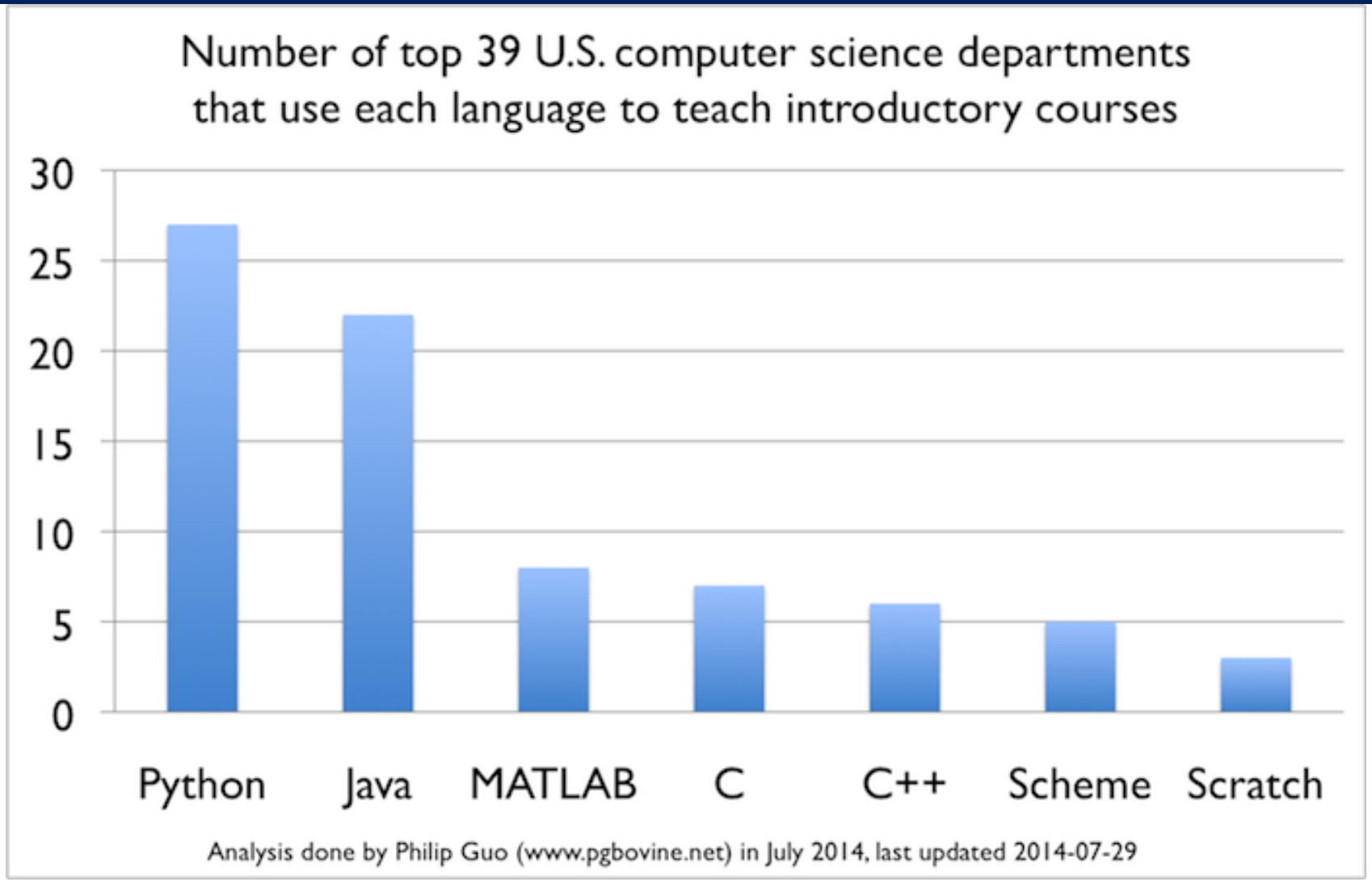
Python > C:

- **12%** retained (2014)
- **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]
```

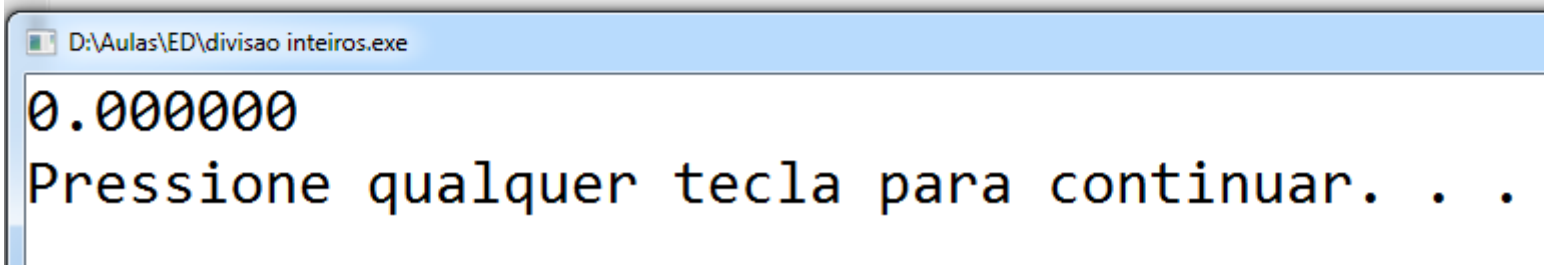
Big integers

```
>>> 2 ** 1024
179769313486231590772930519078902473361797697894230657273430081157732675805500963132708477322407536021120113879871393357658789768814416622492847430639474124377767893424865485276302219601246094119453082952085005768838150682342462881473913110540827237163350510684586298239947245938479716304835356329624224137216
>>>
```

Natural integer division

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

```c
#include <stdio.h>

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



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

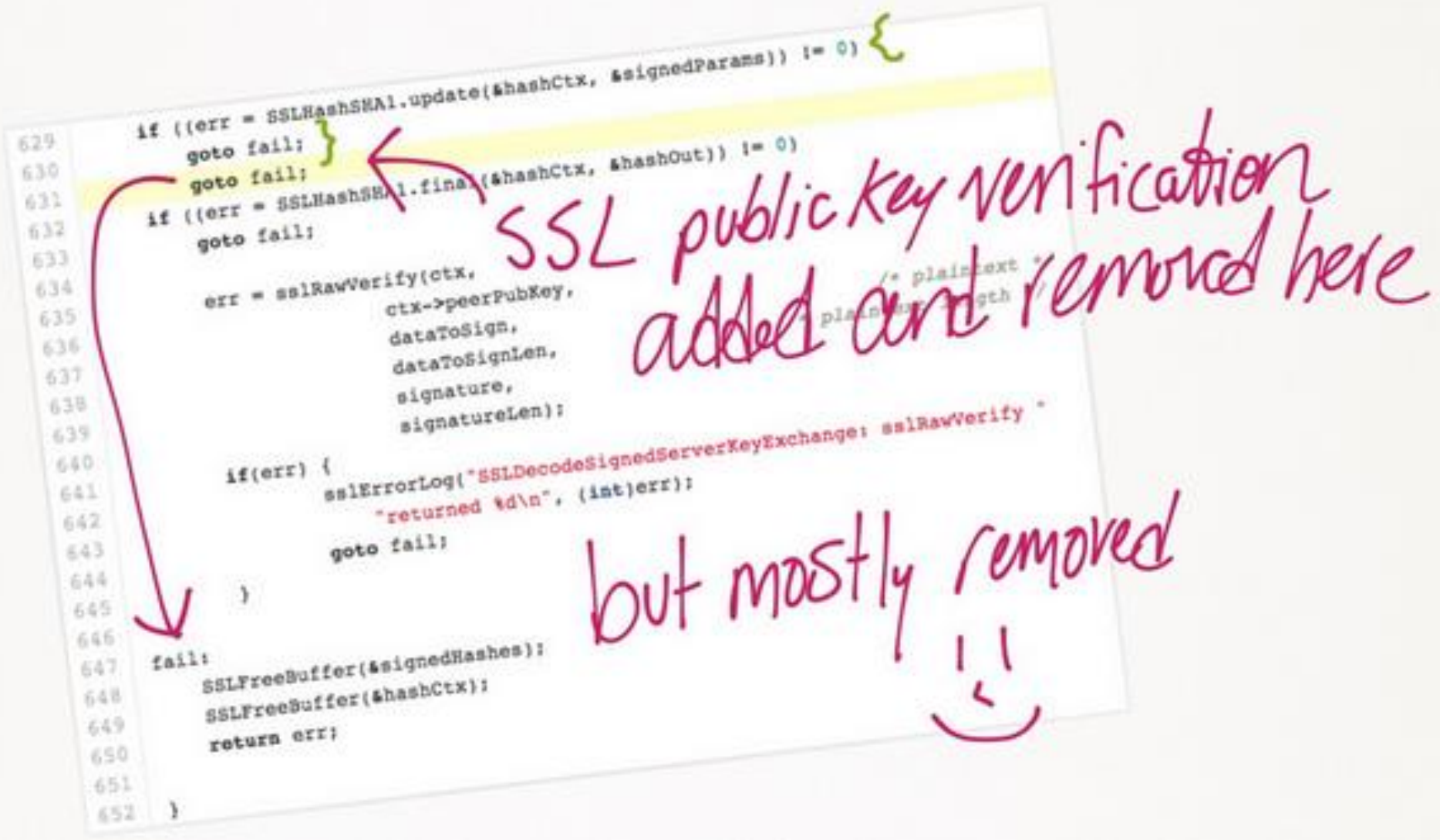
"The programming activity should be viewed as a process of creating works of literature, written to be read. “

--D.E. Knuth

Identation in C

```
1  for (i = 0; i < 10; i++);
2      printf ("Ten times Hello World!");
3
4  if (x < y)
5      if ((pred(x)))
6          printf("One");
7  else if (x == y)
8          printf("Two");
9  else
10         printf("Tree");
```

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 (student solution for dec2bin problem)

```
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

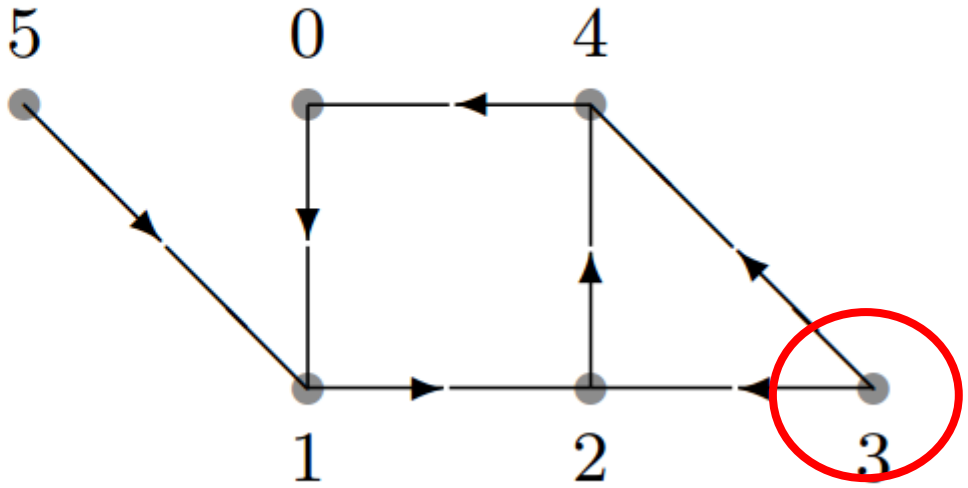
```
17  void Insert (int y, celula *p) {
18      celula *nova;
19      nova = malloc (sizeof (celula));
20      nova->cargo = y;
21      nova->next = p->next;
22      p->next = nova;
23  }
24
25  int main (void){
26      celula head;
27      celula *lst;
28      lst = &head;
29      head.next = NULL;
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]))
```

Word Count

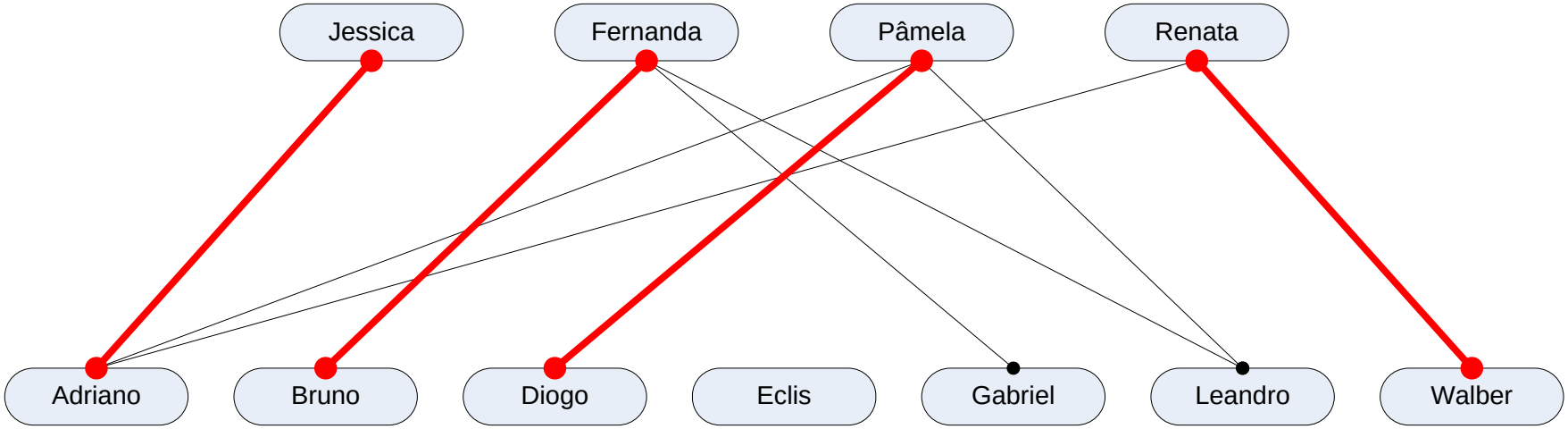
```
with open('alice.txt') as arq:
    texto = arq.read()
    texto = texto.lower()
    import string
    for c in string.punctuation:
        texto = texto.replace(c, ' ')
    texto = texto.split()

    dic = {}
    for p in texto:
        if p not in dic:
            dic[p] = 1
        else:
            dic[p] += 1
```

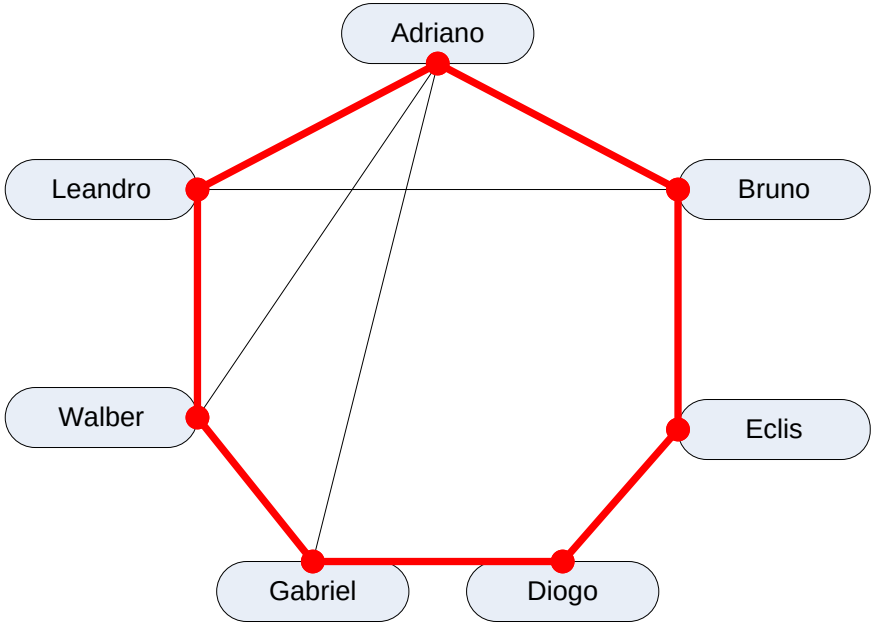
Word Count, please download http://www.gutenberg.org/cache/epub/11/pg11.txt

Projects: Sorting Algorithm comparison

	time(s)			
	Mergesort	Quicksort	Selection	Native
2000	0.05	0.00	0.40	0.00
4000	0.05	0.02	1.65	0.00
6000	0.05	0.03	3.64	0.00
8000	0.07	0.02	6.49	0.00
10000	0.10	0.03	10.16	0.01
12000	0.10	0.05	14.69	0.00
14000	0.13	0.06	19.90	0.02
16000	0.14	0.06	26.55	0.01
18000	0.16	0.08	32.94	0.02
20000	0.20	0.08	42.20	0.02
22000	0.23	0.08	50.67	0.02

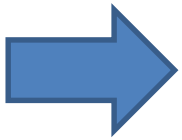
Projects: Arthur Merlin Games simplification





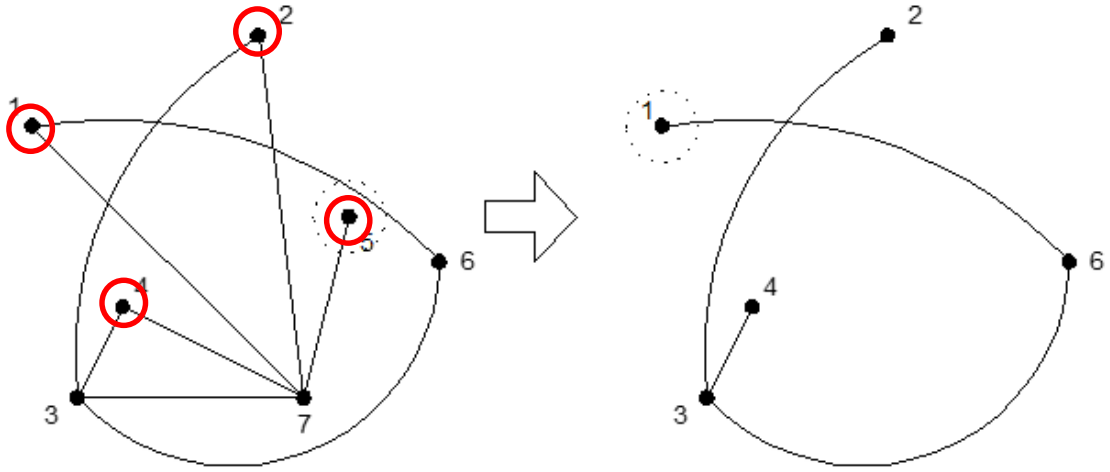
Projects: Binaries regions

```
teste3 = '''0011001010
          0110001010
          0011001110
          0000000000
          0010001010
          0010011111
          1111100000
          0010001110
          0010001110
'''
```



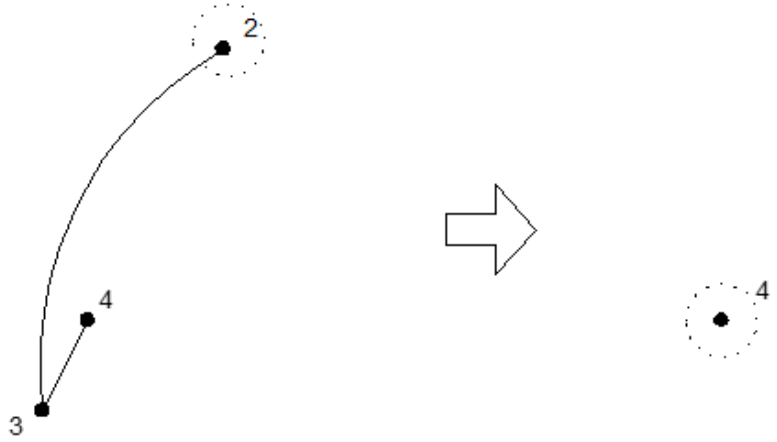
```
0011002020
0110002020
0011002220
0000000000
0030004040
0030044444
3333300000
0030005550
0030005550
```

Projects: Minimum Degree Greedy Heuristic for MIS



S={5}

S={5, 1}



S={5, 1, 2}

S={5, 1, 2, 4}

Conclusions

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

Questions?

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Slides: bit.ly/python-DS