Design and Pedagogy of the Introductory Programming Course

Abhiram Ranade
IIT Bombay

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ACM Compute, Chitkara University, Chandigrah

Educational scenario in India

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Many graduates unemployable

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  Empowering and psychologically liberating if done right!

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- Most course time is spent on language learning.

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Discuss evaluation and pedagogy strategies.

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Correctness issues: Correctly mimic **manual** algorithm.

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Running time analysis: Understand time taken by nested loops.

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Software engineering:

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How to breakup code into functions, classes..

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Standard Library

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- How to motivate students

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Many instructors will appreciate guidance.

Conveying the spirit of the course

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- "New statement": `repeat`

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Introduce programming using “Turtle Graphics”:

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Introduce programming using "Turtle Graphics":

- Invented in 1960s by Seymour Pappert, as part of the Logo programming language for teaching programming to children.

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- Goal of turtle graphics: Draw interesting pictures on the screen.

The "Hello World" program

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Statement is very easy to understand.
Introduced to enable interesting programs from day 1.

Another day 1 program

```
int main(){
  turtleSim();
  repeat(10){
    repeat(4){
      forward(100); right(90);
    }
    right(10);
  }
  wait(10);
}
```

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This is what I ask students. Most figure it out!

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"What do you think it does?"

This is what I ask students. Most figure it out!

Why? Because it is an interesting challenge!

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Students are happy to do this because they can see interesting things happening, they can feel the power.

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Demo conveys what we expect, what is possible after the course.

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repeat(10){forward(i); right(90); i = i + 10;}
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int i=1, sum=0, val=0;
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These idioms would normally be written using `while`/`for`, which are too complicated for week 2.

Teaching program Design

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But they cannot write programs based on simple algorithms!

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What is needed for programming:

- An algebraic description of the computation.

Hypothesis: Students have difficulty in translating from their intuitive/geometric understanding to an algebraic representation.

Towards resolving the crisis

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Pedagogy Proposal 2: We should explicitly teach how to translate from human computation to computer computation

- Human computation does not have "variables".
  Students have difficulty in forming and manipulating variables.
- Humans seem to see everything in a glance.
  A computer operates on few variables at a time.

Example 1: Computing the value of e

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Students actually like this explained...

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- In ith phase, you calculate the value of $\frac{1}{i!}$
  Value calculated in ith phase $= \dfrac{\text{value in } i - 1 \text{ th phase}}{i}$.
- At this point you might realize it is better to give names,
  t_i = term calculated in ith iteration.
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Our suggested strategy: First observe what you do manually

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```
double s=1, t=1;  int i=1, n; cin >> n;
repeat(n-1){
   t = t / i;  s = s + t; i = i + 1;
}
```

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  Fewer choices, less confusion.

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- Place 8 queens on a chessboard so that no queen captures another.

Teaching difficult topics

Difficult topic: Recursion

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With graphics: pictorial recursion

Difficult topic: Recursion

With graphics: pictorial recursion

Tree = trunk + two small trees

```
void tree(int levels){
  if(levels > 0){
    forward(levels*25);            // trunk
    left(15);
    tree(levels-1);                // first small tree
    right(30);
    tree(levels-1);                // second small tree
    left(15);
    forward(-levels*25);
  }
}
```

Difficult topic: Inheritance

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How to construct good motivating examples?

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Simplecpp provides `Composite` class for creating composite objects

Difficult topic: Inheritance

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Simplecpp provides `Composite` class for creating composite objects

```
class Wheel : public Composite{
  Circle *rim;
  Line *spoke[10];
public:
  Wheel(double x, double y, Composite* owner=NULL) :
  Composite(x,y,owner){
    rim = new Circle(0,0,RADIUS,this);
    for(int i=0; i<10; i++){
      spoke[i] = new Line(0, 0, RADIUS*cos(i*PI/5),
      RADIUS*sin(i*PI/5), this);
    }
  }
};
```

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    }
  }
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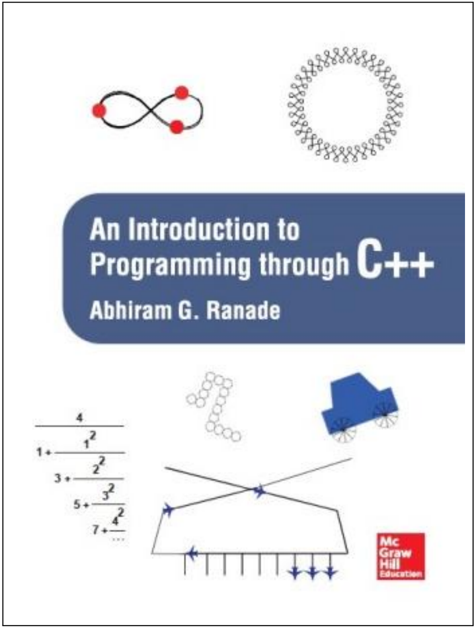
```

Wheels can be created, moved, rotated, just like ordinary graphics objects

Our approach has been documented and tested!

Available in bookstores
Available on-line



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- Chapterwise slides available to instructors.
  Contact McGraw Hill representative.

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  Good first step towards standard looping statements.

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    "Standard difficulties"? How to overcome?
  - Course designers should suggest pedagogy
    How to convey spirit, exams, ...
- Course design should be a well-paid consultancy project?
  Expect professionalism but not altruism.
- Regulatory bodies should monitor, ask compliance?
  Strong medicine, but only for chosen courses.
- Nation-wide electronic discussion forum for teachers?

N. Alzahrani, F. Vahid, A. Edgcomb, K. Nguyen, and R. Lysecky, *Python versus c++: An analysis of student struggle on small coding exercises in introductory programming courses*, Proceedings of the 2018 ACM SIGCSE Technical Symposium on Computer Science Education (New York, NY, USA), SIGCSE '18, ACM, 2018, pp. 86–91.

Jens Bennedsen and Michael E. Caspersen, *Failure rates in introductory programming*, SIGCSE Bull. **39** (2007), no. 2, 32–36.

M. Guzdial, *Is learning to program inherently hard?*, April 2010, Retrieved from: https://computinged.wordpress.com/2010/04/14/is-learning-to-program-inherently-hard/.

Andrew Luxton-Reilly, *Learning to program is easy*, Proceedings of the 2016 ACM Conference on Innovation and Technology in Computer Science Education, ITiCSE '16, ACM, 2016, pp. 284–289.

Leon E. Winslow, *Programming pedagogy – a psychological overview*, SIGCSE Bull. **28** (1996), no. 3, 17–22.

Christopher Watson and Frederick W.B. Li, *Failure rates in introductory programming revisited*, Proceedings of the 2014 Conference on Innovation and Technology in Computer Science Education (New York, NY, USA), ITiCSE '14, ACM, 2014, pp. 39–44.

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- Growth possibility: features such as lambda expressions..