Adopting CS Principles in a Breadth-First Survey Course

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Survey Courses

Problem: how to introduce computer science to new students

- In a way that appeals to a wide audience
- And doesn't focus solely on programming

Late 1980s: ACM task force on the Core of Computer Science (COSC)

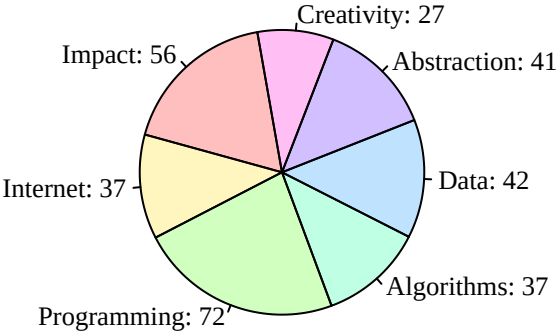
- Proposed a three-course sequence, 42 lectures, 35 labs
- "A rigorous, challenging survey of the whole discipline."

Today: many departments still offer survey courses

- Breadth-first introductions to computer science
- Emphasis on computer fluency, general education

CS Principles

7 big ideas, 44 learning objectives, 312 essential knowledge statements

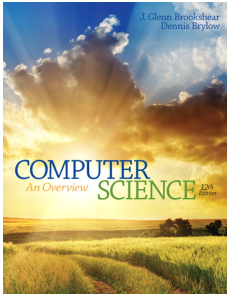


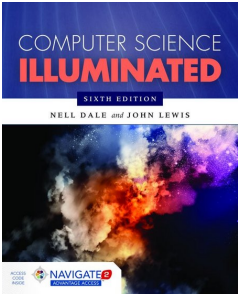
Main Idea of This Paper

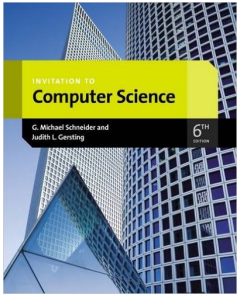
Traditional Survey Course for CS Majors + CS Principles Curriculum Framework = JMU CS 101

	Creativity							Abstraction							Data							Algorithms							Programming							Internet				Impact						
	LO 1.1.1	LO 1.2.1	LO 1.2.2	LO 1.2.3	LO 1.2.4	LO 1.2.5	LO 1.3.1	LO 2.1.1	LO 2.1.2	LO 2.2.1	LO 2.2.2	LO 2.2.3	LO 2.3.1	LO 2.3.2	LO 3.1.1	LO 3.1.2	LO 3.1.3	LO 3.2.1	LO 3.2.2	LO 3.3.1	LO 4.1.1	LO 4.1.2	LO 4.2.1	LO 4.2.2	LO 4.2.3	LO 4.2.4	LO 5.1.1	LO 5.1.2	LO 5.1.3	LO 5.2.1	LO 5.3.1	LO 5.4.1	LO 5.5.1	LO 6.1.1	LO 6.2.1	LO 6.2.2	LO 6.3.1	LO 7.1.1	LO 7.1.2	LO 7.2.1	LO 7.3.1	LO 7.4.1	LO 7.5.1	LO 7.5.2
Online Discussions																																		x	x	x	x	x	x	x	x	x	x	x	x
U1: Introduction			x							x	x		x								x					x		x										x							
U2: Data Storage			x	x		x		x	x	x		x	x							x																									
U3: Program Execution						x		x	x		x	x	x	x								x								x		x	x												
U4: Operating Systems	x		x	x		x					x	x			x	x														x	x									x					
U5: Computer Networking	x	x				x	x	x				x		x			x	x																x	x	x		x	x		x				
U6: Information Security			x		x			x	x						x	x				x			x	x												x	x				x	x			
PT1: Explore/Impact	x	x	x	x		x														x																		x		x	x	x	x	x	
U7: Algorithms and Python			x		x	x				x	x										x	x				x		x	x	x	x	x	x												
U8: Programming Languages	x	x		x	x			x		x	x	x									x	x					x		x	x	x														
U9: Software Engineering				x		x				x		x	x															x			x	x							x		x				
U10: Data Structures						x		x	x			x	x				x		x			x	x								x	x	x												
U11: Database Systems	x		x		x						x				x	x		x	x			x					x		x				x					x		x	x		x		
U12: Artificial Intelligence	x		x	x	x	x					x			x							x	x	x		x			x	x			x	x												
PT2: Create/Program		x		x	x		x			x	x										x	x					x		x	x	x	x	x												

Example Textbooks







Currently using Brookshear and Brylow (2015), *Computer Science: An Overview*

Some Context

About my institution

- Teaching-oriented, public university
- 19K undergrad, 2K grad, over 500 CS majors
- 18 CS faculty (all full-time, tenure track)

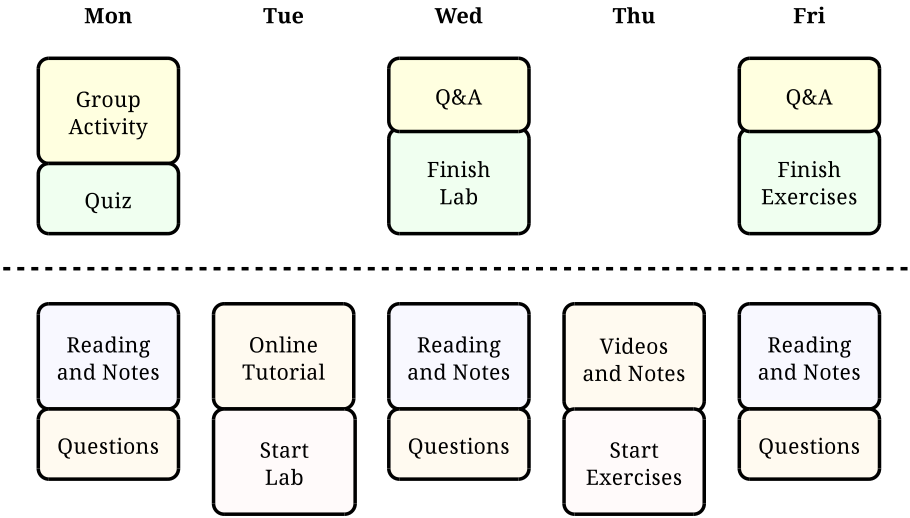
About the course

- CS 101, Introduction to Computer Science
- Offered as an elective, will be required soon
- 2–3 sections per year, 25–30 students each

Course Goals

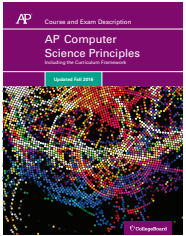
- Provide our majors with a common language and broad understanding of CS that will help them put the rest of their coursework into a larger context.
- Align with the proposed AP CS Principles course that seeks to broaden participation in computing in K-12 education.
- Give non-majors a unique opportunity to learn how to think like a computer scientist, without having to take a programming-intensive course.

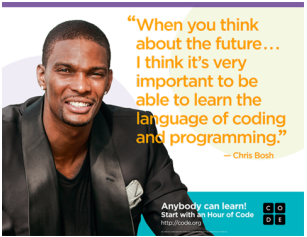
Flipped Classroom



Assessment

- **30% Participation**: labs and exercises, online discussion posts, group activities
- **50% Quizzes**: vocab matching, multiple choice, fill in the blank, short answer
- **10% Explore Task**: collaborative research paper and poster presentation
- **10% Create Task**: pair programming assignment and individual reflection





Curriculum and Labs

Unit 1: Introduction

Algorithms, metacognition, history of computing, seven big ideas

Lab: Lightbot Hour of Code

http://lightbot.com/hocflash.html

CSP: Creativity 1.2.2; Abstraction 2.2.1, 2.2.2, 2.3.1; Algorithms 4.1.1, 4.2.4; Programming 5.1.2; Impact 7.1.1

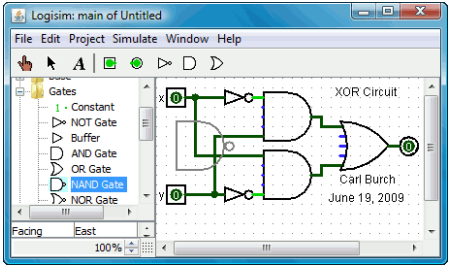
Unit 2: Data Storage

Logic gates, binary, hexadecimal, RAM, hard disk, ASCII, overflow

Lab: Logisim ripple carry adder

http://www.cburch.com/logisim/

CSP: Creativity 1.2.2, 1.2.3, 1.2.5; Abstraction 2.1.1, 2.1.2, 2.2.1, 2.2.3, 2.3.1; Data 3.3.1



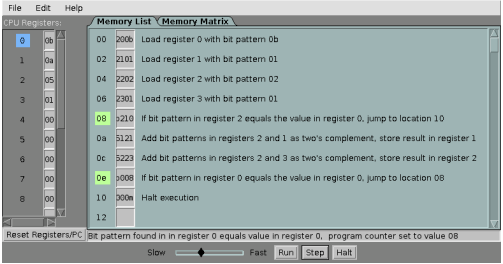
Unit 3: Program Execution

How CPUs work, instructions, machine cycle, code vs data, masking

Lab: Machine language simulator

http://bmachine.sourceforge.net/

CSP: Creativity 1.2.5; Abstraction 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.3.1, 2.3.2; Algorithms 4.1.2; Programming 5.2.1, 5.4.1, 5.5.1



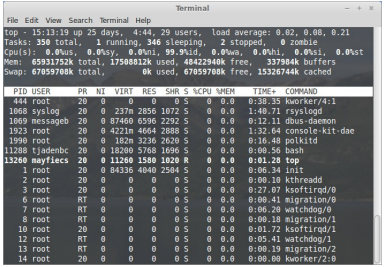
Unit 4: Operating Systems

Job scheduling, multitasking, components of OS, firmware, processes

Lab: Unix commands and files

http://www.ee.surrey.ac.uk/Teaching/Unix/

CSP: Creativity 1.1.1, 1.2.2, 1.2.3, 1.2.5; Abstraction 2.2.2, 2.2.3; Data 3.1.1, 3.1.2; Programming 5.2.1, 5.3.1; Impact 7.3.1



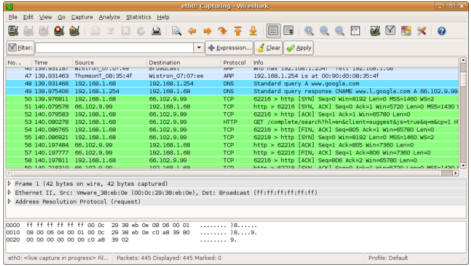
Unit 5: Computer Networking

Protocols, routers, client/server, Internet, IP, DNS, URLs, HTML

Lab: Wireshark, mtr, web tools

https://www.wireshark.org/

CSP: Creativity 1.1.1, 1.2.1, 1.2.5, 1.3.1; Abstraction 2.1.1, 2.2.3, 2.3.2; Data 3.1.3, 3.2.1; Internet 6.1.1, 6.2.1, 6.2.2; Impact 7.1.1, 7.1.2, 7.3.1



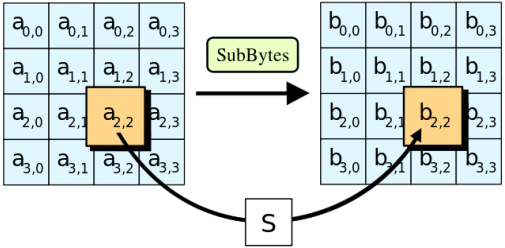
Unit 6: Information Security

Access control, privilege levels, malware, DoS, encryption, keys

Lab: Telnet vs ssh, encryption

http://extranet.cryptomathic.com/aescalc

CSP: Creativity 1.2.2, 1.2.4; Abstraction 2.1.1, 2.1.2; Data 3.1.1, 3.1.2, 3.3.1; Algorithms 4.2.1, 4.2.2; Internet 6.2.2, 6.3.1; Impact 7.3.1, 7.4.1



Unit 7: Algorithms and Python

Primitives, pseudocode, problem solving, decisions, loop control

Lab: Intro to Python and IDLE

http://codingbat.com/python

CSP: Creativity 1.2.2, 1.2.4, 1.2.5; Abstraction 2.2.1, 2.2.2; Algorithms 4.1.1, 4.1.2, 4.2.4; Programming 5.1.2, 5.1.3, 5.2.1, 5.3.1, 5.4.1, 5.5.1

Unit 8: Programming Languages

Paradigms, compiler vs interpreter, variables, functions, scope

Lab: Finch robot dance party

http://www.finchrobot.com/

CSP: Creativity 1.1.1, 1.2.1, 1.2.3, 1.2.4; Abstraction 2.1.1, 2.2.1, 2.2.2, 2.2.3; Algorithms 4.1.1, 4.1.2; Programming 5.1.1, 5.1.3, 5.2.1, 5.3.1

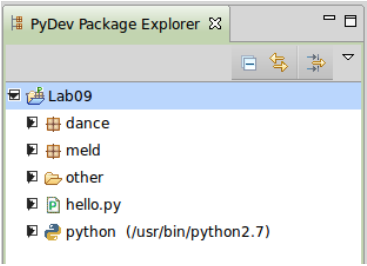
Unit 9: Software Engineering

Software life cycle, prototyping, coupling, cohesion, UML diagrams

Lab: Static analysis, debugging

http://www.aptana.com/

CSP: Creativity 1.2.3, 1.2.5; Abstraction 2.2.1, 2.2.3, 2.3.1; Programming 5.1.2, 5.3.1, 5.4.1; Impact 7.1.2, 7.3.1



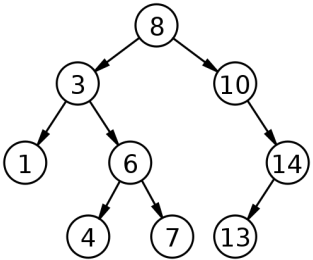
Unit 10: Data Structures

Arrays, lists, stacks, queues, trees, pointers, contiguous vs linked

Lab: Visualizing binary trees

http://pythontutor.com/

CSP: Creativity 1.2.5; Abstraction 2.1.1, 2.1.2, 2.2.3, 2.3.1; Data 3.1.3, 3.2.2; Algorithms 4.1.2, 4.2.1; Programming 5.3.1, 5.4.1, 5.5.1



Unit 11: Database Systems

File system vs DBMS, schemas, relational model, SQL, data mining

Lab: Exploring your SQLite data

http://sqlite.org/

CSP: Creativity 1.1.1, 1.2.2, 1.2.4; Abstraction 2.2.2; Data 3.1.1, 3.1.2, 3.2.1, 3.2.2; Algorithms 4.1.2; Programming 5.1.1, 5.1.3, 5.5.1; Impact 7.1.1, 7.2.1, 7.3.1, 7.5.1

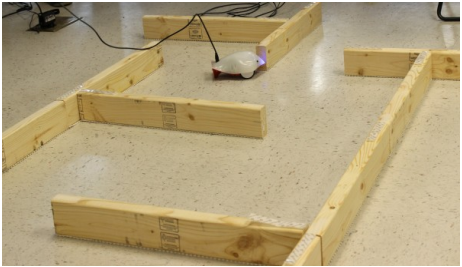
Unit 12: Artificial Intelligence

Turing test, semantics, production systems, state graph, heuristics

Lab: Finch robot obstacle course

http://www.finchrobot.com/

CSP: Creativity 1.1.1, 1.2.2, 1.2.3, 1.2.4, 1.2.5; Abstraction 2.2.2, 2.3.2; Algorithms 4.1.1, 4.1.2, 4.2.1, 4.2.3; Programming 5.1.2, 5.1.3, 5.4.1, 5.5.1



Evaluation and Reflection

Pre/Post Survey

1. How confident are you that you are able to do the following?
   - 5-point scale: apprehensive to confident
   - List of 10 representative learning objectives
2. Rate your interest in the following areas of Computer Science.
   - 5-point scale: uninterested to interested
   - List of 12 main chapters from the textbook
3. Additional open-ended questions on the post-survey:
   - How has taking CS 101 benefited you?
   - What advice would you give a student taking CS 101?

Quantitative Results

Data collected from first three years of the course

- About 150 students, 18% female, 48% non-major

Confidence

- Slight increase overall (female went up, male went down)
- Not surprising given the grades/experience of students

Interest

- Slight decrease overall (about the same for male/female)
- More interested in CS as a whole, less in specific sub-areas

Qualitative Results

Retention

- "I'm more comfortable working with not only computers, but the software we've used like Wireshark, IDLE, and SQLite." (CS major, female)
- "It gave me a more in-depth knowledge in the field . . . by teaching material that can actually help you in other CS classes." (CS major, male)
- "I have learned that CS is not for me, but I find it very fascinating." (Undeclared, male)

Recruitment

- "Taking this class has taught me a ton of valuable information. I took this class to see if I wanted to switch majors to CS, and now I do." (Nursing major, male)
- "101 has increased my interest in the computer science field. I have enjoyed each chapter and definitely want to continue studying it." (Undeclared, female)
- "I didn't think I would actually enjoy CS, but this course made me realize that I actually do, especially programming." (Philosophy major, female)

Thank You!

https://w3.cs.jmu.edu/cs101

(Google: JMU CS 101)