Computer Science Education: Challenges and Directions

Marie desJardins, Penny Rheingans, and Susan Martin

CE21 – Maryland Mini-Summit

UMBC, August 8, 2012

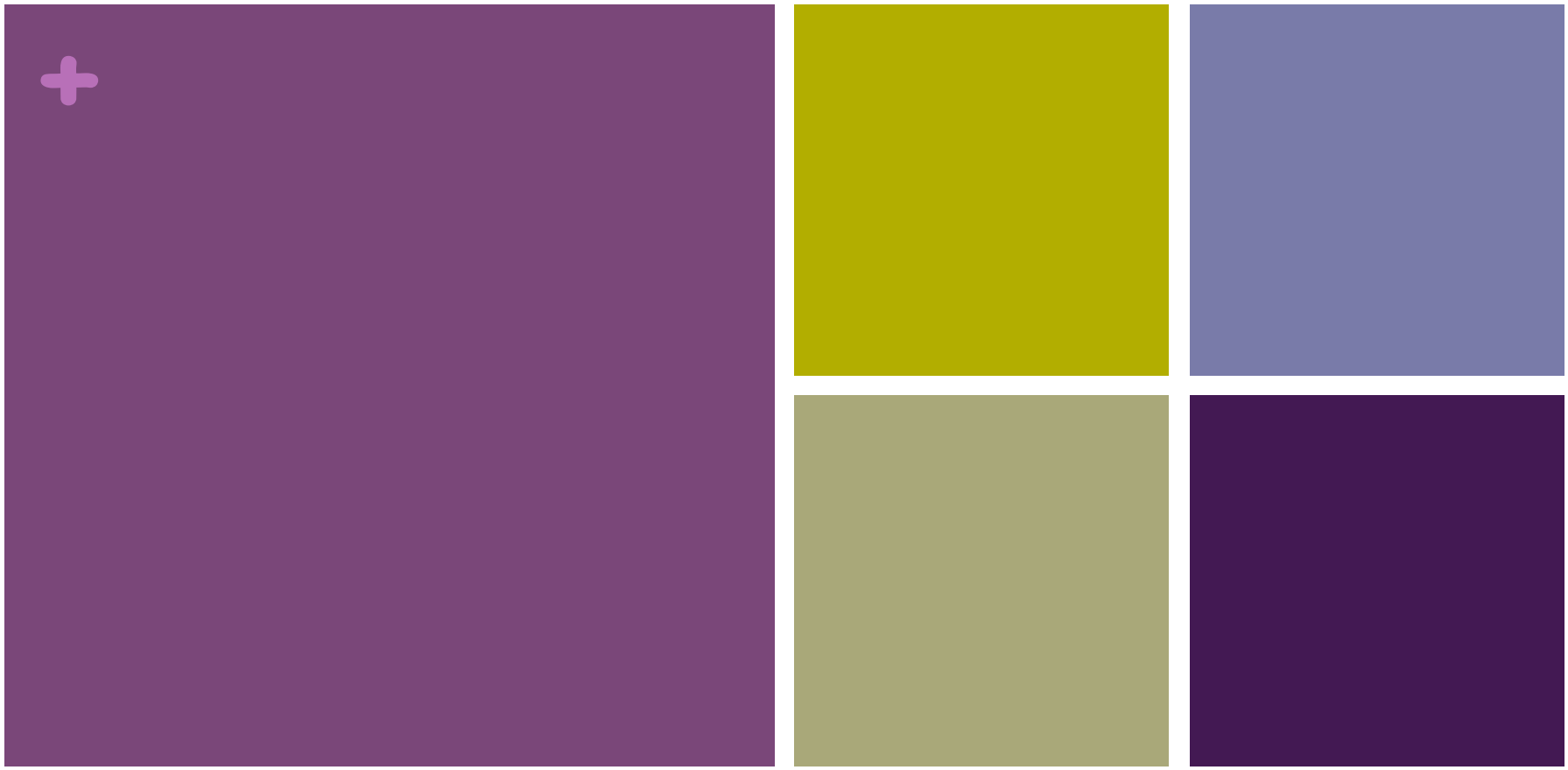
Overview and Welcome

- Welcome to UMBC!
- Setting the context: Why are we here?
- Challenges in Computer Science Education
  (and what we're trying to do about it...)
  - Broadening the classroom view of CS
  - Broadening the diversity of CS students
  - Broadening the pool of qualified CS teachers
  - Broadening access to CS education through curricular reform
- Overview of mini-summit

Welcome to UMBC!

UMBC Team

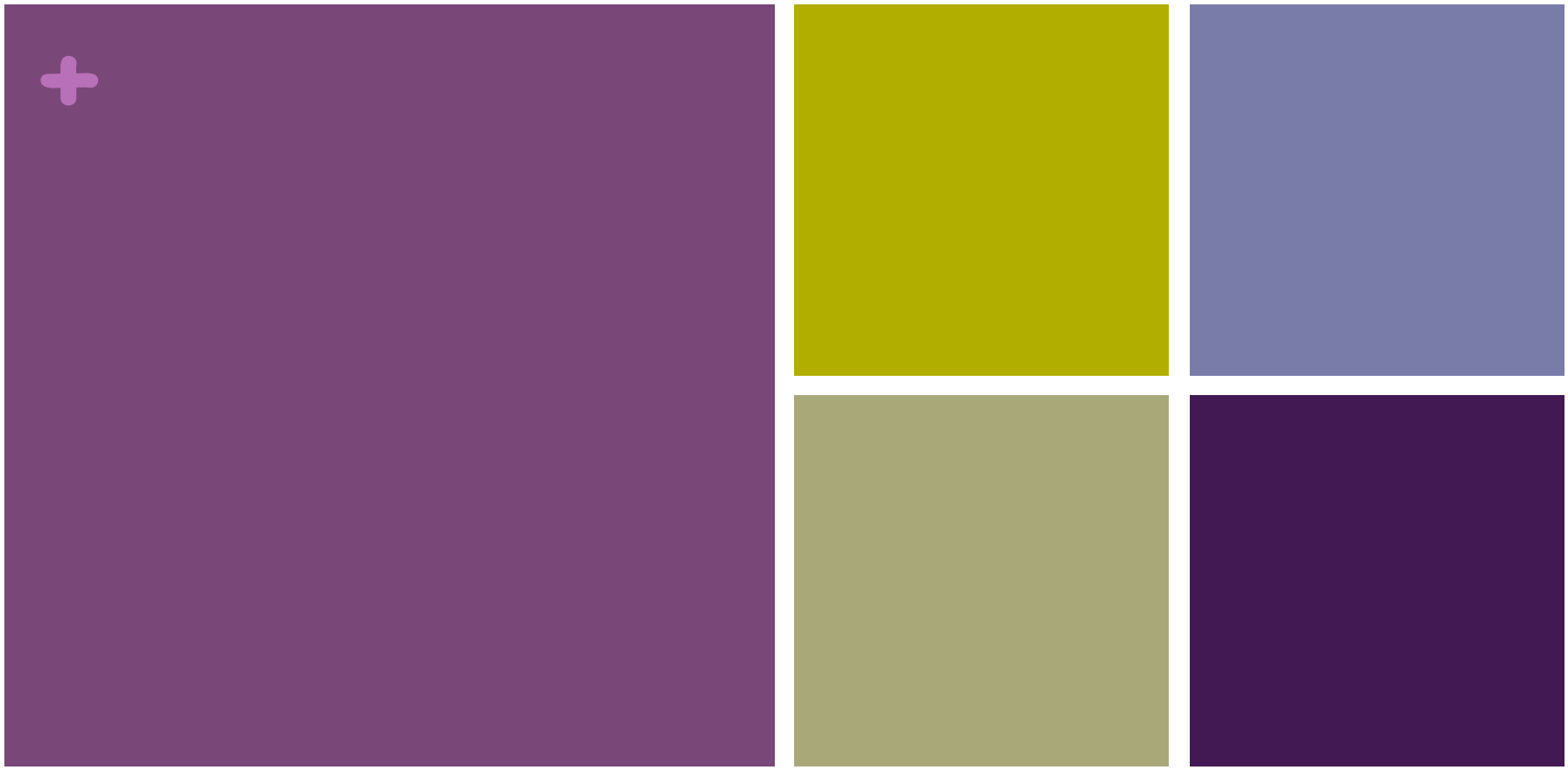
- Dr. Marie desJardins (Professor of Computer Science)
  - Maryland native (Wilde Lake High School '81)
  - Artificial intelligence researcher
  - 11 years of teaching and mentoring at UMBC
- Dr. Susan Martin (Associate Director, Center for Women in Technology)
  - Ed.D. in Higher Education administration
  - Nearly 20 years of higher education experience (counseling, advising, and program coordination)
- Dr. Penny Rheingans (Professor of CS; CWIT Director)
  - Graphics and visualization researcher
  - 14 years of teaching and mentoring at UMBC



Setting the Context

CS Education: A National Crisis

- We need many trained computer scientists
  - There will be more new jobs in computing than in ***all other areas of STEM combined***
- We are not producing enough computer scientists
  - Enrollment in computing majors dropped dramatically in the 2000s
  - Recently, enrollments have increased, but not nearly enough
- Our pool of computer scientists is not sufficiently diverse
  - Women, African-Americans, and other ethnic minorities choose CS at a much lower rate than white males
- We don't have enough highly qualified K-12 CS teachers
- We don't have a strong K-12 CS curriculum



Challenges in CS Education

CS is Not Just Programming and Video Games!

- Stereotypical view of CS:
  - CS is mostly about programming
  - The part that isn't about programming is about video games and hacking
  - The typical computer scientist is an asocial, nerdy, young white male who likes to play video games and works all alone in a cubicle all day
  - CS isn't a good career for someone who wants to make a difference in people's lives

WRONG!

Computer Science is About…

- How computers are built, programmed, and used to solve problems
  - **Hardware**: Digital logic, representing data, system architecture
  - **Systems**: Operating systems and networks
  - **Theory**: Algorithms, computation, complexity
  - **Software**: Programming languages, compilers, databases
  - **Applications**: Artificial intelligence, graphics, simulation, bioinformatics, health informatics, visualization,…
  - **Social issues**: Ethics, privacy, environmental impact, patent/copyright issues, usability, accessibility

Interdisciplinary Diversity of CS

- CS is inherently mathematical
  - We reason about processes and quantities (discrete mathematics, statistics, automata theory)
- CS is directly related to engineering
  - We build our computing methods on top of hardware platforms (electrical engineering, materials science, communications engineering, photonics/optics, mechanical engineering/robotics)
- CS connects to the visual arts
  - Interfaces require human understandability (aesthetics, graphic design, perceptual modeling, kinesthetics)

Interdisciplinary Diversity of CS

- CS applications often help to solve and model scientific problems (biology, chemistry, medicine, physics, astronomy)
- Building CS systems requires understanding human behavior(psychology, sociology, computational economics, linguistics)

- **Computer science lies at the boundary between mathematics, science, and engineering, and helps us to understand, interact with, and control the world around us**

Computational Thinking: A New Perspective

- National conversation surrounding the teaching and "perception" of computing
- Move away from focus on programming, keyboarding, and narrow technical skills
- Move towards a focus on the broad and important themes of computer science:
  - "Computational Thinking"
  - New AP CS Principles course **(CS4HS session)**
- **Related efforts at UMBC:**
  - **CMSC 100 (intro for non-majors, aligned with CS Principles)**
  - **"Computational Thinking 101" (design-based intro course for computing majors, funded by NSF's Transforming Undergraduate Education in STEM program)**

Lack of Gender Diversity in CS*

- In 2008, women earned:
  - 57% of all Bachelor's degrees
  - 61% of Master's degrees
  - 51% of Doctoral degrees
- But in 2008, women earned:
  - 12% of Bachelor's degrees ***in CS (the lowest percentage ever recorded)***
  - 26% of MS degrees in CS
  - 21% of PhD degrees in CS
- ***Women are underrepresented in CS by a factor of more than 2 at the grad level, and by a factor of more than 4 at the undergrad level!***
- **Related efforts at UMBC:**
  - **CWIT Scholarship Program**
  - **CWIT Affiliates Program**

* Statistics for CS, CE, and IS combined
Source: CRA Taulbee Survey

Lack of Racial Diversity in CS

- In 2008, of Bachelor's degrees in CS:
  - 4.9% went to African-Americans (9.8% of all Bachelor's)
  - 6.8% to Hispanics (7.9% of all Bachelor's)
- In 2008, of Master's degrees in CS:
  - 2.7% went to African-Americans (10% of all Master's)
  - 2.4% went to Hispanics (5.9% of all Master's)
- In 2008, of PhD degrees in CS:
  - 1.6% went to African-Americans (6.1% of all PhDs)
  - 1% to Hispanics (3.6% of all PhDs)
- ***Minorities are underrepresented by a factor of 4 at the grad level***
- ***(CS4HS session on diversity)***
- **Related efforts at UMBC:**
  - **Meyerhoff Scholarship Program**

Source: CRA Taulbee Survey

Challenges in Teacher Preparation

- In most states (including Maryland!!):
  - Certification requirements are unclear
  - Current certifications do not meet the needs of the discipline
  - Teachers without CS certification are often asked to teach CS classes (often due to a lack of certified/qualified teachers)
  - There is inadequate in-service professional development to keep teachers abreast of new trends and knowledge
- **Related efforts at UMBC:**
  - CS4HS summer workshops
  - Proposed BS/MAT program would lead to CS certification, optionally with dual certification in mathematics
  - Planned larger professional development summer program to be submitted to NSF's CE21 program

Challenges in K-12 Curriculum

- In most states (including Maryland!):
  - Very few of the CSTA-identified K-12 CS standards are part of the standard curriculum*
  - Computer science classes are not required for graduation, and in most cases don't count towards any graduation requirement
  - Many schools don't offer computing courses beyond the level of keyboarding schools, and even fewer offer college preparatory CS courses
- **Related efforts at UMBC:**
  - NSF-funded "CE21: Maryland" to gather data and build community to improve CS education in Maryland

* CSTA data on Maryland standards: 31 out of 35 Level I standards; 3 out of 10 Level II standards; 1 out of 10 Level III standards.

CS4HS/Mini-Summit Overview

- Monday sessions:
  - Computing Education for the 21st Century (challenges and directions)
  - AP Computer Science Principles
  - Hands-on session: Finch Robots
  - Dinner with Industry
- Tuesday sessions:
  - Cyber Security
  - Hands-on session: Scratch Programming
  - Strategies for Increasing Diversity
  - Hands-on session: Mobile App Development

CS4HS/Mini-Summit Overview (cont.)

- Wednesday sessions:
  - Presentations and wrap-up
  - CS4HS Recap (for minisummit attendees)
  - Joint keynote: Jan Cuny, NSF Program Director
  - CSTA Community Meeting and Social Lunch

- Wednesday minisummit:
  - Session 1: Snapshot of High School CS in Maryland
  - Session 2: Sharing Best CS Education Practices
  - Session 3: Planning the Spring 2013 CE21 Summit