

Cultivating a Robotics Workforce from Computer Science Majors: Seven Years of Lessons

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1

Robotics Industry Concerns

- ⦿ A Growing Field....
 - ⦿ Manufacturing
 - ⦿ Domestic Robots, Eldercare, Security, Military, Surgery, Entertainment,
 - ⦿ Robotics Industry Association: 30% growth in 2005....

- ⦿ ...Needs a Growing Workforce
 - ⦿ 12,000 more 2006–2016 in programming positions

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2

CS Majors to the Rescue?

- ⦿ CS Bachelors in 2006 (US):
 - ⦿ 12,000 in PhD-granting departments
 - ⦿ another 10,000 in non-doctoral departments
- ⦿ New Declared CS Majors in 2006: up 10% from 2005

- ⦿ Source: Taulbee Survey 2007 www.cra.org

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3

Computer Science Ed's Concerns

- ⦿ Enrollment in Engineering & Computer Science Majors

- ⦿ Robotics (among other applications) Looks Enticing
 - ⦿ Popularity from Roomba, Lego, Mars Rovers, FIRST contests
 - ⦿ Robotics needs a "rough and ready" programming attitude
 - ⦿ E.G. "Sensor values change while I'm not looking"
 - ⦿ Still difficult to support in smaller schools

- ⦿ Eye-Candy Suspicion

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4

What Should the Robotics Industry Do?

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5

Studies of Interest

⦿ US Air Force Academy (Fagin & Merkle, 2003)

- ◊ Fagin & Merkle, "Measuring the Effectiveness of Robots in Teaching Computer Science," Proceedings of the 34th SIGCSE Symposium, 2003.

⦿ Villanova University (Klassner)

- ◊ Klassner, "A case study of lego mindstorms' suitability for artificial intelligence and robotics courses at the college level." Proceedings of the 33rd SIGCSE Symposium, 2002.
- ◊ Klassner, and Anderson, "Lego MindStorms: Not Just for K-12 Anymore" IEEE Robotics and Automation Magazine, vol. 10, no. 2, June 2003
- ◊ Klassner, "Launching into AI's 'October Sky' with Robotics and Lisp" AI Magazine, AAAI Press, Spring 2006.
- ◊ Klassner, & Continanza, "Mindstorms Without Robotics: An Alternative for Systems Courses" Proceedings of 38th SIGCSE Symposium, 2007.

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6

Interesting Case Features

- ⊗ Small Schools
- ⊗ Non-doctoral Programs
- ⊗ No Robotics In Curricula
- ⊗ (Villanova) No pursuit of robotics careers

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7

USAFA Study: Parameters

- ⊗ Introductory CS Course: Ada/MindStorms
- ⊗ 884 Freshmen
 - ⊗ 709 non-robotics; 175 robotics
- ⊗ Majors declared by Sophomore year
- ⊗ 6 Open Labs/semester
 - ⊗ Team-Based
 - ⊗ Restricted to Lab Rooms

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8

USAFA Study: Results

- ⦿ Findings
 - ⦿ No Statistically Significant Influence on Major Choice
 - ⦿ Grades in Programming Portions of Exams
 - ⦿ Robotics was lower than non-Robotics.
- ⦿ Take-Home Lessons
 - ⦿ Lack of Simulator
 - ⦿ Restriction to Lab Room Perceived as Disadvantage
 - ⦿ Student Feedback Improves with Instructor Experience

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9

Villanova Study: Background

- ⦿ NSF DUE 0088884 & NSF CISE 0306096
- ⦿ Investigate MindStorms Effectiveness Throughout CS Curriculum
- ⦿ Develop 22 Laboratory Modules Across Curriculum
 - ⦿ <http://www.mcs.alma.edu/LMICSE/>
 - ⦿ Java, C/C++, Lisp
- ⦿ Train 150+ Instructors Nationwide in Mindstorms' Use

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10

Villanova Study: Parameters

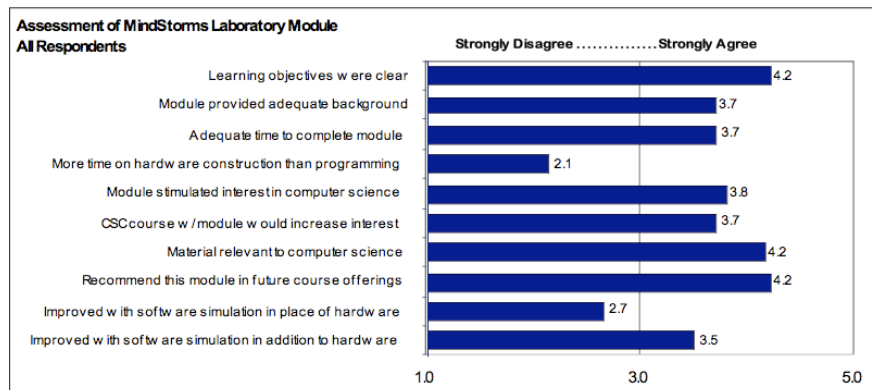
- 212 Students; 4 Years
 - Introductory, Intermediate, and Advanced Courses
- Instructor Trainees Vetted Laboratory Modules
- Study Projects:
 - CS 0, 1, 2: "Loops and Conditionals"
 - Systems: "Simon Says," "Euclid Meets the RCX," "USB Drivers"
 - AI/ML: "Capture the Ping-Pong Balls," "Emergent Behavior"
 - Same "Instructor" Throughout

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11

Villanova Study: Results

- Findings (Overall):



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12

Villanova Study: Results

- ⦿ Findings (Specific):
 - ⦿ Women in intro courses reported slightly lower interests
 - ⦿ Preference for simulator+hardware combination
 - ⦿ 60% Trainees Use MindStorms Within 12 Months of Training
- ⦿ Take-Home Lessons:
 - ⦿ CS Students can see robotics-topics as germane to computing
 - ⦿ Emphasize programming experience over hardware
 - ⦿ Robotic platforms need to be “portable” and/or accessible

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13

Villanova Anecdotes

- ⦿ More students interested in robotics:
 - ⦿ 2004-2008: AI course stays at “healthy” enrollment of 10-12
 - ⦿ 2004: Two MS graduates enter robotics doctoral programs
 - ⦿ 2006-7: Three majors work senior project for C/C++ programming for robotic camera arm.
 - ⦿ 2008: One sophomore JPL undergraduate student intern
 - ⦿ Recruitment: 2-3 (out of 25) new students come in with FIRST competition experience

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14

Industry Recommendations

- ⦿ Encourage Adoption of Your Platform or Robotics into Curricula, not Courses.
 - ⦿ Provide sample labs for different types of courses
 - ⦿ More cost-effective for smaller colleges
 - ⦿ Avoid “Eye-Candy” Suspensions
 - ⦿ Support “Out of the Box” code examples
 - ⦿ Support multiple languages

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15

Industry Recommendations

- ⦿ Support educator training
 - ⦿ Formally or informally
 - ⦿ BUT...be sure to help trainees get recognition back at their institution!
 - ⦿ Cost Issues
 - ⦿ Help increase mathematical breadth
 - ⦿ Make guest lecturers available where feasible

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16

Industry Recommendations

- ⦿ Help Create Scalable Simulation Packages
 - ⦿ Ameliorate “locked lab” syndrome
 - ⦿ Open Source is nice, but keep installation simple
 - ⦿ Online help is ... helpful!

Thank You

Q & A