

# On the Quorum Programming Language and including Exceptional People in Computer Science

***INCLUDES 2017***

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*University of Nevada, Las Vegas*

*(with special thanks to Richard Ladner)*

## Computer Science Teachers have a smorgasbord of Technology Choices


Create stories, games, and animations  
Share with others around the world



A creative learning community with **16,296,518** projects shared

- Tools like Scratch or SNAP! are popular for small projects
- Others prefer more general purpose tools (e.g., Python, Java, JavaScript)
- Many of these tools do basically the same thing. How do we choose and does it even matter?

## Many technology designers make claims



Scratch Create Explore Discuss Help Search Join Scratch Sign in

Create stories, games, and animations  
Share with others around the world

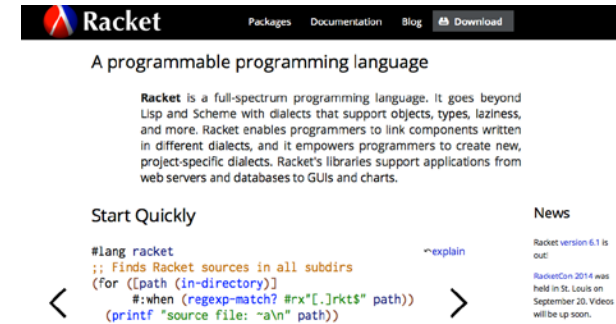
TRY IT OUT SEE EXAMPLES JOIN SCRATCH (It's free)

A creative learning community with 6,491,154 projects shared

ABOUT SCRATCH | FOR EDUCATORS | FOR PARENTS

```

when clicked
  repeat 10
    move 10 steps
    change color by 25
    play drum 4 for 0.2 beats
    say Welcome to Scratch! for 2 secs
  
```



Racket Packages Documentation Blog Download

A programmable programming language

Racket is a full-spectrum programming language. It goes beyond Lisp and Scheme with dialects that support objects, types, laziness, and more. Racket enables programmers to link components written in different dialects, and it empowers programmers to create new, project-specific dialects. Racket's libraries support applications from web servers and databases to GUIs and charts.

Start Quickly

```

#lang racket
;; Finds Racket sources in all subdirs
(for ([path (in-directory)]
      #:when (regexp-match? #rx"[.rkt]" path))
      (printf "source file: ~a\n" path))
  
```

News

Racket version 6.1 is out:  
RacketCon 2014 was held in St. Louis on September 20. Videos will be up soon.



akka

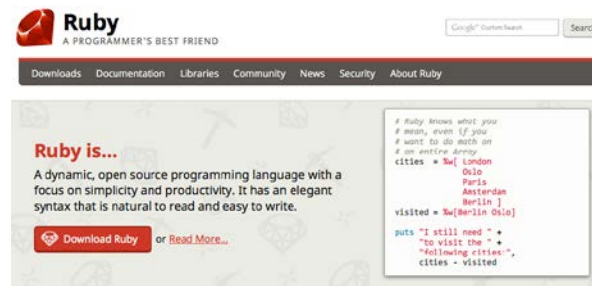
Build powerful concurrent & distributed applications more easily.

Simple Concurrency & Distribution  
Asynchronous (no Distributed by design. High-level abstractions like Actors, Futures and STM).

Elastic & Decentralized  
Adaptively load balancing, routing, partitioning and configuration-driven messaging.

Extensible  
Use Akka Extensions to adapt Akka to fit your needs.

Akka is a toolkit and runtime for building highly concurrent, distributed, and fault-tolerant event-driven applications on the JVM.



Ruby A PROGRAMMER'S BEST FRIEND

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Ruby is...

A dynamic, open source programming language with a focus on simplicity and productivity. It has an elegant syntax that is natural to read and easy to write.

```

# Ruby knows what you # mean, even if you # want to do math on # an entire array
cities = %w[ London Paris Amsterdam Berlin ]
visited = %w[ Berlin Oslo ]

puts "I still need " + "to visit the " + "following cities:", cities - visited
  
```

Download Ruby or Read More...



The Haskell Programming Language

Haskell is an advanced purely functional programming language. An open source product of more than twenty years of cutting-edge research, it allows rapid development of robust, scalable, correct software. With strong support for modularity with other languages, built-in concurrency and parallelism, debuggers, profilers, rich libraries and an active community, Haskell makes it easier to produce flexible, maintainable, high-quality software.

Learn Haskell

- What is Haskell?
- Who created your browser?
- Learning Haskell
- Books & Articles
- Library documentation
- School of Haskell, hosted by FP Complete

Use Haskell

- Language specification
- Applicability and Examples
- Usage and usage API/learn
- IDEs, Editors, and Tools

Join the Community

- Haskell on reddit, Slack, StackOverflow, G+
- Haskell on IRC channels
- Wiki How to contribute
- Communities and Activities reports
- Haskell in industry, research and education
- Planet Haskell @ The Monocle Reader
- Local user groups



The Perl Programming Language www.perl.org

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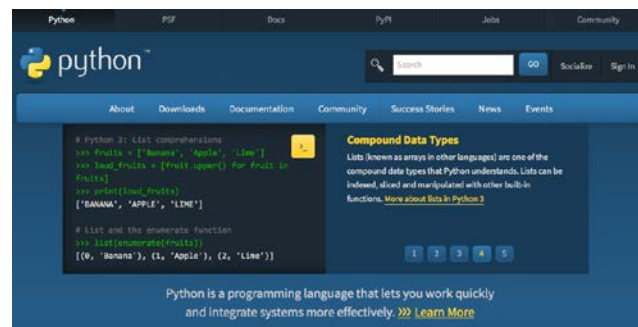
Tip  
Perl -- When the best is good enough.

Sponsor YellowBus Local Search

Learning Perl 5  
With free online books, over 25,000 extension modules, and a large developer community, there are many ways to learn Perl 5.

The Perl Community  
Perl has an active world wide community with over 300 local groups, mailing lists and support/discussion websites.

Documentation Contribute to Perl



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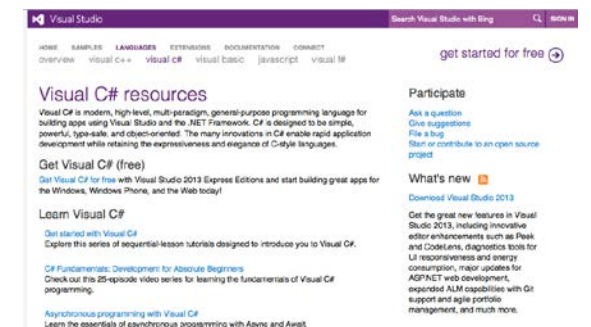
```

# Python 3: List comprehensions
fruits = ['Banana', 'Apple', 'Lime']
last_fruits = [fruit.lower() for fruit in fruits]
print(last_fruits)

# List and the enumerate function
for (i, banana), (j, 'Apple'), (k, 'Lime')
  
```

Compound Data Types  
Lists (known as arrays in other languages) are one of the compound data types that Python understands. Lists can be indexed, sliced and manipulated with other built-in functions. More about Lists in Python?

Python is a programming language that lets you work quickly and integrate systems more effectively. >>> Learn More



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Visual C# resources

Visual C# is modern, high-level, multi-paradigm, general-purpose programming language for building apps using Visual Studio and the .NET Framework. C# is designed to be simple, powerful, type-safe, and object-oriented. The many innovations in C# enable rapid application development while retaining the expressiveness and elegance of C-style languages.

Get Visual C# (free)  
Get Visual C# for free with Visual Studio 2013 Express Editions and start building great apps for the Windows, Windows Phone, and the Web today!

Learn Visual C#  
Get started with Visual C#  
Explore this series of sequential-lesson tutorials designed to introduce you to Visual C#.

CF Fundamentals: Development for Absolute Beginners  
Check out this 25-episode video series for learning the fundamentals of Visual C# programming.

Asynchronous programming with Visual C#  
Learn the essentials of asynchronous programming with Async and Await

Participate  
Ask a question Give suggestions File a bug Start or contribute to an open source project

What's new  
Download Visual Studio 2013  
Get the great new features in Visual Studio 2013, including innovative editor enhancements such as Peek and CodeLens, diagnostics tools for L3 responsiveness and energy consumption, major updates for ASP.NET web development, expanded ALM capabilities with Git support and agile portfolio management, and much more.

# Programming Languages are used by *many* kinds of people

- Programming languages are used throughout the world for many reasons
  - Professionals at companies use them (\$331.7 Billion in Wages/year, U.S.)
  - College students learn them
  - Children play/learn
  - People of other demographics (e.g., the 11% of undergraduates with disabilities)
- There are thus many different designs
  - Different kinds of features (e.g., visualizations, syntax, type systems)
  - Different kinds of libraries (e.g., robotics, games, science, web)
  - Designers/academics make many marketing claims (e.g., natural and easy to use, efficient, simple)

## People have varied needs and experiences when coding

- Consider the following people in the classroom:
  - **Middle school** aged child of wealthy parents that has used a computer since an early age
  - **High-school** aged child with no computer experience
  - **Legally blind** child wanting to write a 3D computer game
- Consider the following professionals:
  - **Microsoft employee** with 10 years of C++ and a CS M.S. on the autism spectrum
  - Web developer **just out of college** at Amazon learning Perl
  - Systems developer **nearing retirement** that has only ever used the console

### Observation:

*Programming language and curriculum designers should, in theory, take all of our needs into account*

This talk is about **people** coding, namely

- The different ways in which students with disabilities interact with the computer and how this impacts us in computer science education
- Programming languages, and the curriculum that use them, and how this impacts people in computer science
- The Quorum programming language and resources available to you as a teacher

How do people with disabilities use a computer?

## Disabilities come in many forms

- Vision
  - Blind
  - Low-Vision
  - Color Blind
- Hearing
  - Deaf
  - Hard of Hearing
- Speech
  - Ability to speak
  - Stuttering
- Mobility
  - Ability to walk
  - Ability to use hands/arms
- Cognition
  - Dyslexia
  - Short-term memory loss
- Multiple
  - Deaf-blind
  - Speech-mobility



## High Variability

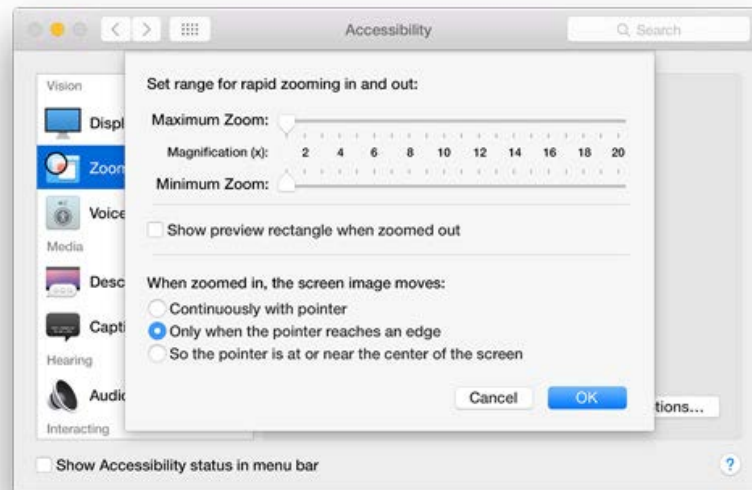
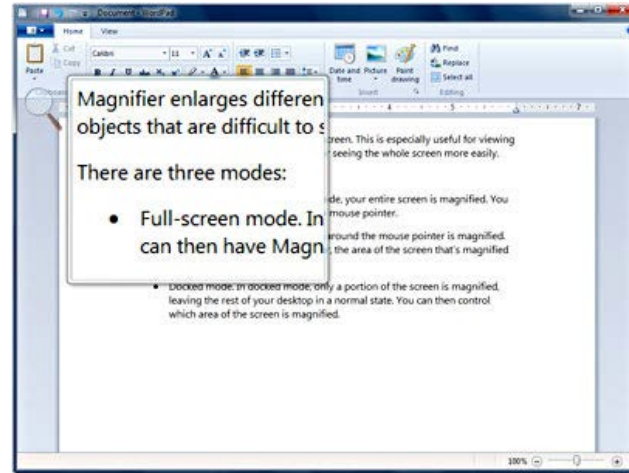


- Even with the same function, there is high variation in accessibility needs. Example:
  - Sign language
  - Captioning
  - Lip Reading
- Vision Examples
  - Example: One of my legally blind ex-students can drive in North Carolina (legally)
  - Example 2: Many blind students create 2D or 3D **visual** computer games using the Quorum programming language

# Vision

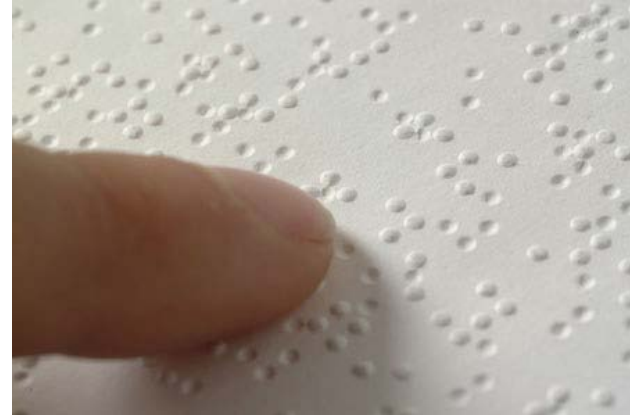
## Built-in Magnification

- Window magnifier
- Apple zoom



# Braille

- Braille Translation
  - Duxbury
  - Braille 2000
- Braille Printers



# Braille Displays



Notetakers



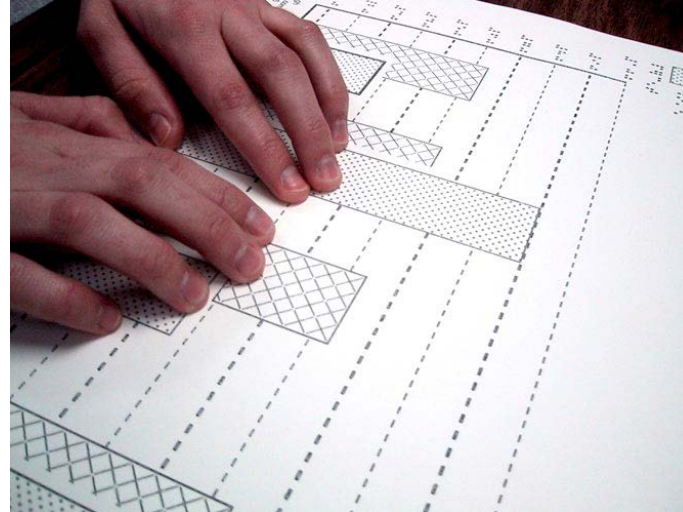
Large Display



Small Braille I/O

# Tactile Graphics

- Embosser
- Swell paper



# Screen Reader



# Accessible Apps and Webpages

- Web Content Accessibility Guidelines 2.0
  - <http://www.w3.org/TR/WCAG20/>
- Microsoft Accessibility
  - <http://www.microsoft.com/enable/>
- Apple Accessibility
  - <https://www.apple.com/accessibility/>



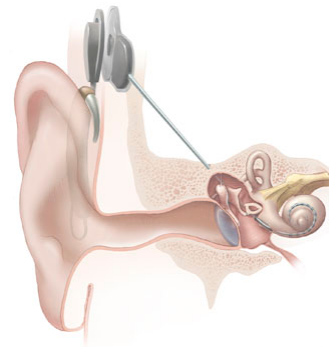
Hearing

# Hearing Technology

- Smart Hearing Aids



- Cochlear Implants



- FM Systems



# Typical Classroom Accommodations

- Interpreters
- Real-time captionists
- Hearing aids
- FM systems
- Note takers



Summer Academy for DHH 2007 – Intro to Programming

## CART

- Communication Access Real-time Translation
  - Word-for-word
  - Delay
- [Video](#)



# Accessible Audio-Video

- Captioning Companies
  - Caption Colorado
  - WGBH
  - CaptionSynch
- DIY
  - YouTube Captioning
  - Video editing software

Mobility

## Speech Input



Dragon Naturally Speaking



# Ergonomic Keyboards

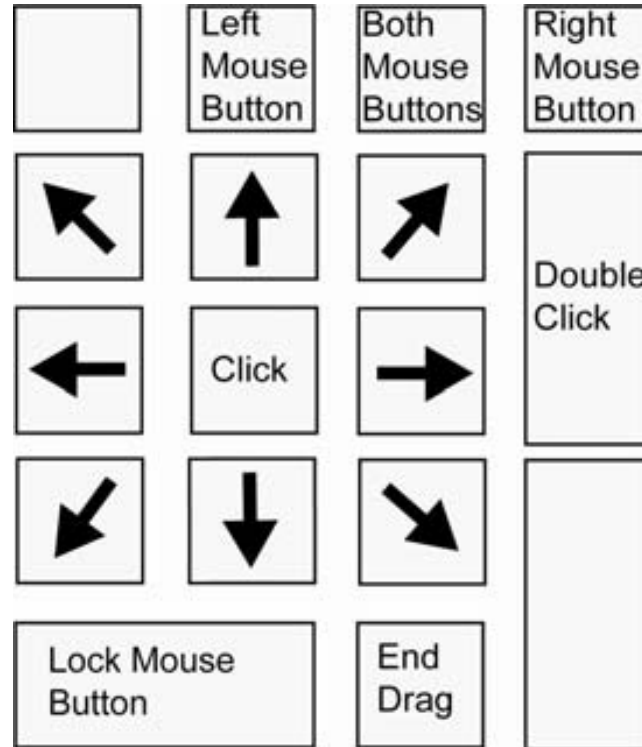




# Large Keyboards



# Mouse Keys



## Windows Mouse Keys

# Switches



Sip and puff switch

# Eye-Gaze



Tobii Eye Tracker

Learning

# Note Taking Technology



Livescribe Smartpen

# Speech Input/Output



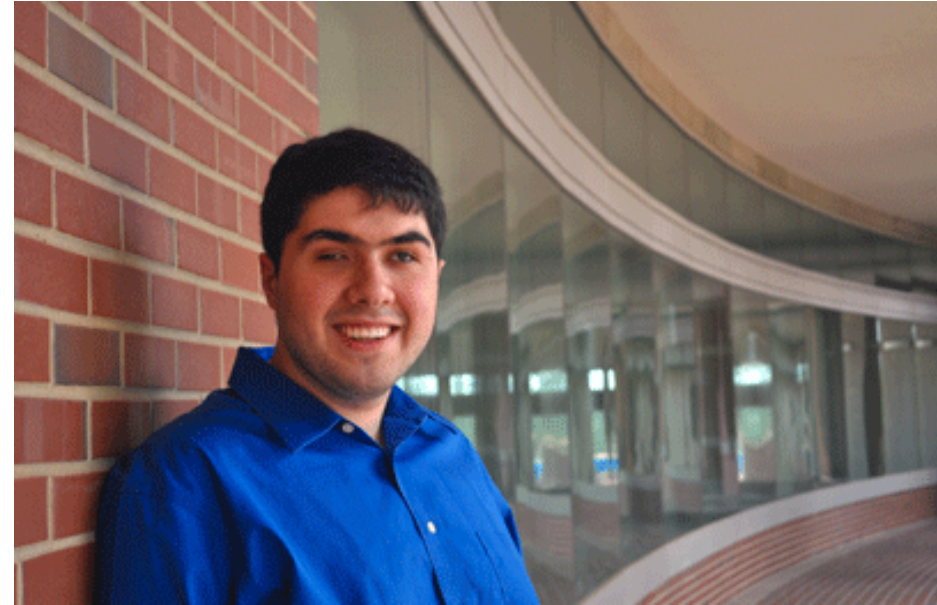
Dragon Naturally Speaking or screen readers

What about programming languages and curriculum?



Some in Computer Science are having a “Crisis of Faith” about our “evidence” standards

- In my case, this started by a long-term investigation into how blind and visually impaired people program
- Modeling is heavily studied and almost never used (Petre, 2013)
- Software Engineers generally do not trust scholarly research papers on software engineering (Devanbu, Zimmerman, Bird, 2016). Should they?



Sina Bahram  
White House Champion of Change  
Prime Access Consulting

<https://pac.bz/>

Marian Petre. Uml in practice. In *Proceedings of the 2013 International Conference on Software Engineering*, ICSE '13, pages 722–731, Piscataway, NJ, USA, 2013. IEEE Press.

Prem Devanbu, Thomas Zimmermann, and Christian Bird. 2016. Belief & evidence in empirical software engineering. In *Proceedings of the 38th International Conference on Software Engineering* (ICSE '16). ACM, New York, NY, USA, 108-119. DOI:

<https://doi.org/10.1145/2884781.2884812>

## In Education, Scholarly “belief” appears to be incorrect on how students code

- Brown and Altadmri have one of the more complete sets of data that involve student errors
  - 900,000 student users, predominately in an intro to Java course
  - 100 million compiler errors
  - Lots of great data on the impact on student’s use of Java
- However, educators and education researchers, both from the top CS ed conference (ICER), but also others (e.g., SIGCSE, local UK venues) reveal that such folks ***are not particularly good at predicting student problems*** and, surprisingly, that ***experience does not help***

But ... why? As it happens, scholars are not gathering data.

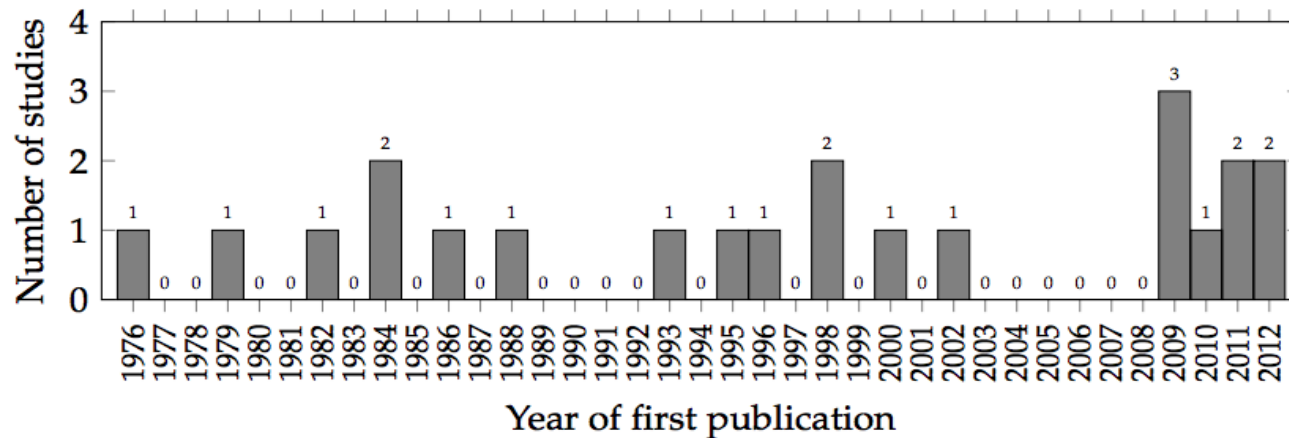


FIGURE 10 The number of randomized controlled experiments in the core per publication year

**Only 22 Randomized controls trials ... from the 1950's to 2012!**

So scholars started investigating ...

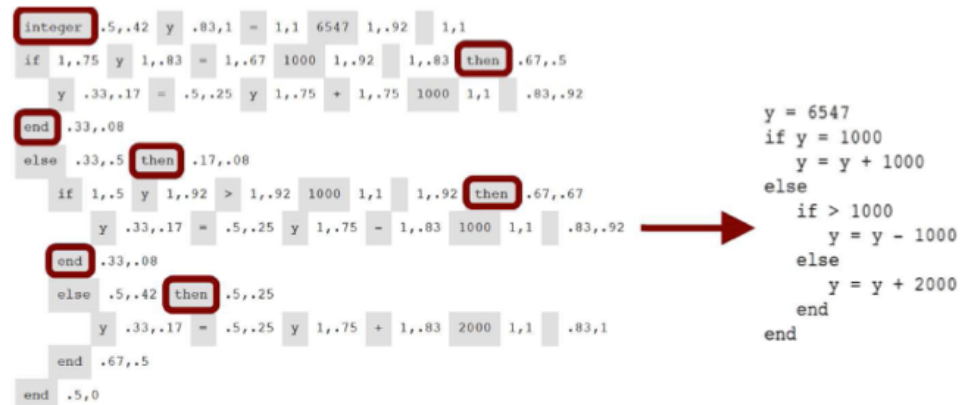
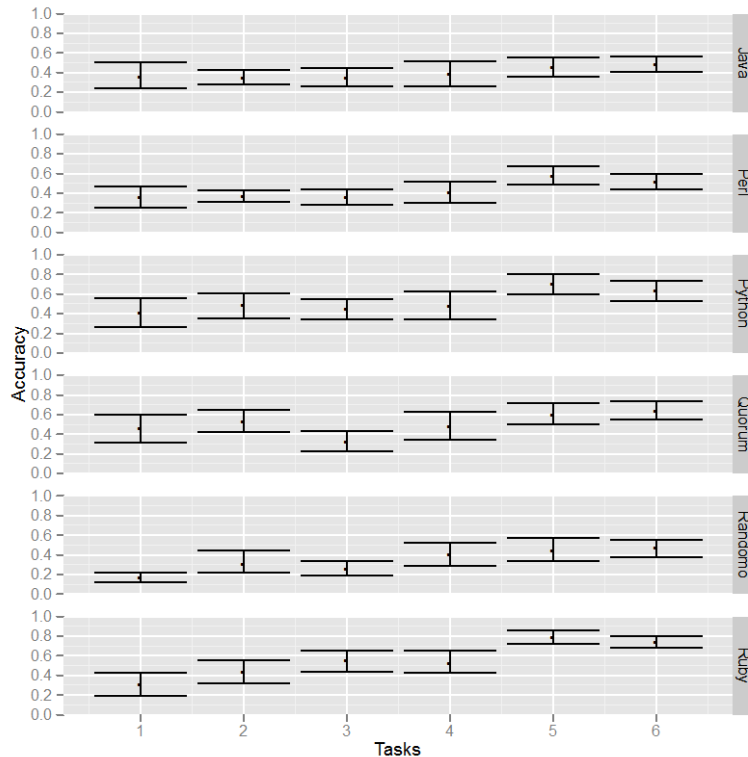


Fig. 5. A summary of the Token Accuracy Map (TAM) for Quorum 1.0, Task 6, with trouble spots in the language circled. The right-hand side shows the modified syntax for Quorum 1.7. For each number next to a highlighted token (e.g., then, integer), is two numbers. The left number is the proportion of individuals that correctly placed that token in the example in experiment 3, whereas the right number shows experiment 4.

*Token Accuracy Maps tell us which tokens cause problems*

Type system decisions (e.g., `a = 5` or `int a = 5`?) matter for human productivity

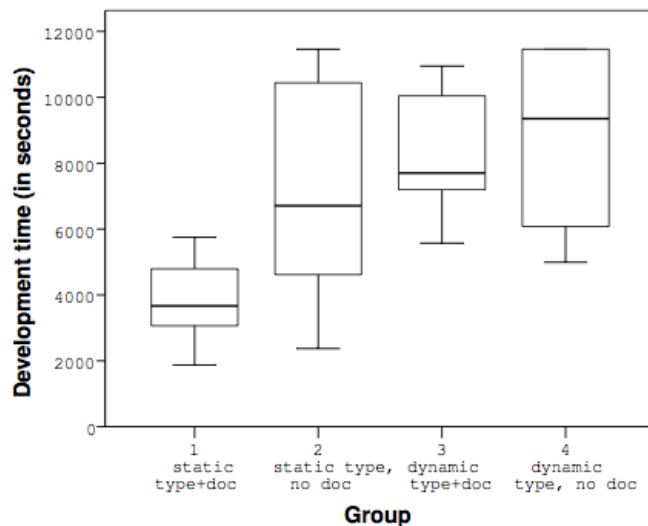


Figure 3: Boxplot for raw development time measurements

ICSE 2014

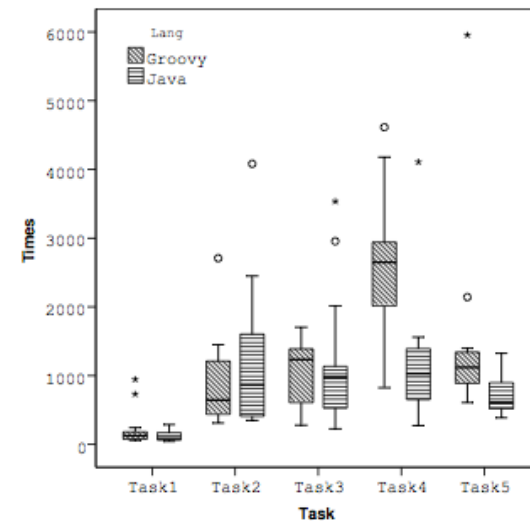
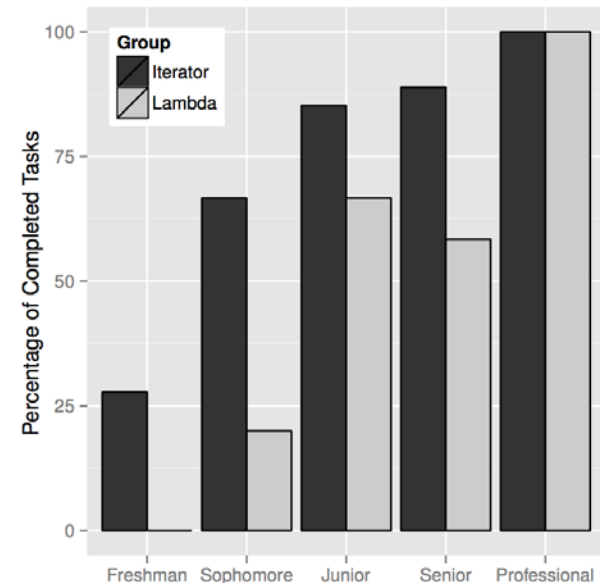


Figure 7. Boxplot for second round (no repeated measurement of same tasks)

OOPSLA 2012

# How about Lambdas, like in C++ or SNAP!?

- To my knowledge, there has been only one test
- The test was in C++ and compared lambdas to iterators
- The test showed a negative impact for students and no impact for seasoned professionals with expertise in lambdas



**Figure 5: The percentage of tasks completed by participants at each experience level.**

# The Quorum Programming Language



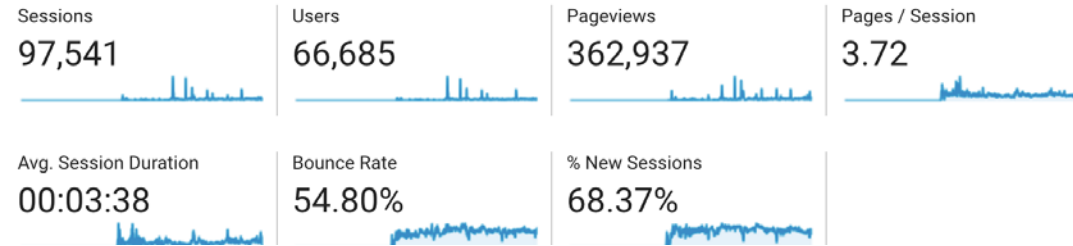
- Our goal is to make a programming language that has a scientific foundation of evidence for design decisions
- It is heavily funded by the National Science Foundation
- It is inclusive and used heavily by schools around the globe
- It is accessible and well tested by many different kinds of people



# Quorum is being Used Worldwide




## Quorum Views since mid-2013









# Quorum has extensive, teacher designed, curriculum



**Learn**  
Each track provides curriculum that can be freely used in the classroom.

**Quick Introduction to Quorum** | **Hour of Code**

 <b>Core Track</b>	 <b>Visual Track</b>	 <b>Audio Track</b>	 <b>Robotics Track</b>
Learn to code in Quorum with basic lessons. This track is no frills and dives straight into basic programming skills.	Learn to code in Quorum with lessons that incorporate visual programming.	Learn to code in Quorum with lessons that incorporate audio programming.	Learn to code in Quorum with lessons that incorporate robotics programming. This track requires access to a LEGO™ robot kit

- A wide variety of engaging online or offline activities are available, like:
  - 2D/3D Games support (with physics)
  - Extensive Audio support
  - LEGO robotics
- The curriculum is iteratively refined every year by teachers and tech experts

# Quorum Usage and Learning

- **Quorum is under the BSD License**
  - Free for commercial or non-commercial use
  - The source code is freely available
  - You can modify it or use it in any way you wish
- **Curriculum and Documentation**
  - Documentation is under the creative commons license
  - You can modify or use it in any way you wish, but ...
  - The one limitation is that you can't just put your name on top of the documentation and sell it
- **Annual Professional Development**
  - Next year in Austin, TX in mid-July
  - Not required, but is especially helpful for teachers learning
  - Financial support for teachers wanting to come out is sometimes available, pending funding for that year

This year, partner teachers can request support through “EPIQ Grants”

- Reader's Digest Partners for Sight Funded
- Grants available during the year for teachers to hold "events" around programming and Quorum
  - Programming clubs
  - Programming summer workshops
  - Local mini-EPIQs
  - Local events of your design
- Quorum has a vibrant and fun community of teachers and students. An EPIQ grant is a nice way to get your feet wet!

## Summary

- Programming can be inclusive to all without much leg work
- Students with disabilities use a variety of technologies, some of which work in the computer science classroom and others do not
- Whether a student with a disability can participate depends in large part on which technologies and curriculum you choose
- Programming languages today are undergoing rapid change, including an organized push toward standards of evidence
- Quorum is one choice in a sea of alternatives, but it is free, iteratively refined by teachers across the country, has a foundation of evidence you can lookup, and is accessible to diverse learners