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

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Andreas Stefik
University of Nevada, Las Vegas
(with special thanks to Richard Ladner)
Computer Science Teachers have a smorgasbord of Technology Choices

- 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
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

No Function                                               High Function

• 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/
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.

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

Kaijanaho, A.-J., Evidence-Based Programming Language Design: A Philosophical and Methodological Exploration. PhD Diss., Information Technology Faculty, University of Jyväskylä, 2015, Jyväskylä, Finland. 222.
So scholars started investigating ...

**Token Accuracy Maps tell us which tokens cause problems**

Type system decisions (e.g., \(a = 5\) or \(\text{int } a = 5\)?) matter for human productivity

*In this context, we are referring to static typing where the annotations are made explicit.*
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

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

<table>
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<tr>
<th>Sessions</th>
<th>Users</th>
<th>Pageviews</th>
<th>Pages / Session</th>
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<td>66,685</td>
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Avg. Session Duration: 00:03:38
Bounce Rate: 54.80%
% New Sessions: 68.37%
Quorum has extensive, teacher designed, curriculum

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