Robot Virtual Programming Games that work with NXT-G, LabVIEW, and ROBOTC
What We Will Cover Today

• Introduction
• What are Robot Virtual Worlds
• Research behind Teaching Programming with RVWs
• RVW Resources and Demonstrations
  – Competition Resources
  – Demo of NXT and LabVIEW in RVW
  – Math Tool Integration
  – Level Builder
  – Model Importer
• Recruit Schools and Teachers for our Research Project
Basic robotic research

Applied robotic research

Educational robotic research
National Robotics Engineering Center

Drive state-of-art robotics technologies into every day use
## Robotics Academy Team

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ross Higashi</td>
<td>Curriculum Specialist, Robots In</td>
<td></td>
</tr>
<tr>
<td>Mindy Jang</td>
<td>Research Programmer, Robots In</td>
<td></td>
</tr>
<tr>
<td>Vu Nguyen</td>
<td>Research Programmer, CS2N In</td>
<td></td>
</tr>
<tr>
<td>Timothy Hunkele</td>
<td>Systems Software Engineer, CS2N In</td>
<td></td>
</tr>
<tr>
<td>Jesse Flot</td>
<td>Project Manager, Robot Virtual World</td>
<td></td>
</tr>
<tr>
<td>Timothy Friez</td>
<td>Software Engineer, Multi-Robot Control Project</td>
<td></td>
</tr>
<tr>
<td>Professor Christian Schunn</td>
<td>University of Pittsburgh, LRDC Faculty</td>
<td></td>
</tr>
<tr>
<td>Norm Kerman</td>
<td>Robotics Academy Outreach Coordinator</td>
<td></td>
</tr>
<tr>
<td>Robin Shoop</td>
<td>Project Manager, CS2N</td>
<td></td>
</tr>
<tr>
<td>Krishna Pandravada</td>
<td>Multi-Media Developer, Robot Virtual World</td>
<td></td>
</tr>
<tr>
<td>Thomas Luong</td>
<td>Multi-Media Developer, Robot Virtual World</td>
<td></td>
</tr>
<tr>
<td>Ryan Cahoon</td>
<td>Research Programmer, DML Badges/RoboWorlds</td>
<td></td>
</tr>
<tr>
<td>Louis Alfieri II</td>
<td>Post Doc, University of Pittsburgh</td>
<td></td>
</tr>
<tr>
<td>Jason McKenna</td>
<td>Teacher, Beaver School District/Robomatter</td>
<td></td>
</tr>
<tr>
<td>Dick Swan</td>
<td>Inventor, ROBOTC</td>
<td></td>
</tr>
<tr>
<td>John Watson</td>
<td>Software Support, ROBOTC</td>
<td></td>
</tr>
<tr>
<td>Allison Liu</td>
<td>LRDC Graduate Student</td>
<td></td>
</tr>
<tr>
<td>Rajadurai Balasubramanian</td>
<td>Programmer, Robomatter</td>
<td></td>
</tr>
</tbody>
</table>
Computer Science is the Language of Innovation!

Transportation
- Electronic flight control systems (autopilot, fly-by-wire)
- Route planning (which planes/trucks, which routes)
- Inventory tracking (barcode scanners, RFID, satellites, web interface)
- Airport traffic control

Business & Finance
- High-speed stock trading (algorithms, online trading system)
- Business model and market simulations
- Accounting Software
- E-commerce/Credit Card Processing
- Internet Storefronts
- Router/Network Devices
- Video Monitors/Onscreen Displays

Health Care Equipment
- Heart Monitors
- CT Scanners
- Patient Monitoring
- Medicine

Security
- Security scanners (airports, sports arenas)
- Red light cameras
- Credit card fraud/theft detection
- Facial recognition and identification
- Border sensor networks

Green Homes/Buildings
- “Quality of Life” Smart Homes
  - Remote access to senior citizen homes
  - Smart kitchens and bathrooms
  - Medicine dispensers and monitors
- Thermostats HVAC
- Solar/Wind/Geothermal Systems

Embedded Systems
- Cars
- Cell Phones
- Modern Appliances (microwaves, refrigerators, stoves, dryers, washers)
- Industry/Factory automation
- Robots
- CNC machinery

Entertainment Media
- Video games
- Special effects (algorithmic filters)
  3D crowd imagery (movies with lots of digital "extras")
- Motion capture
Build New Levels, Import New Elements, Use the Measurement Tools
Robot Virtual Programming Games that now work with NXT-G, LabVIEW, and ROBOTC

High End Graphics And Gamelike

Story Driven Gameplay
Description of the Research

We recruited a teachers that:

• Taught multiple sections of Level One robotics during the same semester
• Agreed to use the same curriculum in each section
  • Use the same tests, challenges, and lectures.
• Agreed to have all students take pre and posttests
• Agreed to have one class use Robot Virtual World simulations and have the other class use physical robots
Research Results

**Students Learn Programming Faster Through Robotic Simulation**

By Allison Lin, Jeff Neven, Chris Schum, and Robin Shyri

Robotic systems are everywhere—just drive through any urban locale, and you will see robots everywhere. They are in homes, offices, medical settings, and on the streets. Many people are using robots in everyday life, and they are becoming more prevalent in jobs and tasks previously performed by humans. This trend is expected to continue, with the global market for robotic systems projected to reach $152 billion by 2024.

The Brains of the System

The learning of robotic systems is driven by computer science (CS) and artificial intelligence (AI). The field of robotic systems is rapidly expanding, with new technologies and applications being developed at an accelerated pace. This trend is expected to continue, with the global market for robotic systems projected to reach $152 billion by 2024.

A recent study by Carnegie Mellon Robotics Academy has found that students who learn programming through robotic simulation can achieve better outcomes compared to those who learn through traditional methods.

**Pretest score vs posttest score. Points above the line improved on the posttest compared with the pretest.**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Pre-Test Average</th>
<th>Post-Test Average</th>
<th>Average Time Taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical</td>
<td>50.2 (SD=11.2)</td>
<td>82 (SD=10.6)</td>
<td>85.0 (SD=0.0)</td>
</tr>
<tr>
<td>Virtual</td>
<td>55.9 (SD=11.5)</td>
<td>84.5 (SD=14.6)</td>
<td>54.7 (SD=18.2)</td>
</tr>
</tbody>
</table>

Days taken to complete the course separated by condition.
We compared Jeff’s class with two other CS2N internet based classes that were using only the RVW software and found:

- Similar gains between pre and posttest results.
- And similar amount of time to complete the curriculum in two of the three cases.
Robot Virtual World Technology

Links Virtual Worlds with Reality. Use the Same Language on Virtual and Real Robots

Programmable Interactive Games w/multiple robot types

Story Driven Robot Programming Games

Scaffolded Fun “Edutainment” Environment to Teach Computer Science
Tools to Teach Programming Using Virtual Robots

Current Game-Like Worlds
- Palm Island
- Ruins of Atlantis
- Operation Reset
- FTC & VEX Virtual Programming Only Competitions

Automated Assessment Tools
- RVW Curriculum Companion
- Student Earn Badges
- Expedition Atlantis Math Game

Certifying Teachers
- Computer Science and Robotics Certification
  - Algorithmic Thinking
  - Syntax, Statements, and Structures
  - Robot Mathematics
  - Control and Feedback of Motors and Sensors
  - Boolean Algebra/Conditional Statements
  - Variables/Functions/Parameters
  - Pedagogy
  - Programming User Interfaces
    - Buttons
    - Joystick
  - Troubleshooting/Debugging Code
  - Arrays
  - Case Statements
  - Multi-Tasking
  - Multi-Robot Communications
  - Pointers
  - Recursion
Resources for the Robotics Competition Community

**Toss Up**

**Block Party**

**Supporting Teaching Programming in Classrooms**

For the past two seasons we’ve made two versions of the game. At the top is the actual *FTC Game Simulation* that uses allows both autonomous and driver control.

At the bottom is a specially designed game that we’ve developed specifically to teach robot programming. *This game uses all of the elements of the FTC game, but includes additional features that allows the game to be challenged in an autonomous only mode.*
Multiple Programmable Robot Types

FTC Robots

VEX Robots

Programmable:
- Wheel Encoders
- Arms
- Shoulders
- Intake Mechanisms
- Gyro Sensor
- Light Sensor
- Sonar Sensor
- Remote Controllers
RVW NXT Software January 2014
Robomatter has been working with National Instruments and now has LabVIEW working with RVWs!

LabVIEW RVW Retail Pricing

- Annual Single Seat - $49
- Annual Team License - $149
- Annual Classroom License - $299

- Perpetual Single Seat - $79
- Annual Team License - $299
- Annual Classroom License - $599
Additional Virtual Tools

RVW Measurement Tool Set

The measurement toolkit has been integrated into the curriculum companion and all robot programming games. This allows students to use virtual measurements allowing them to complete calculations BEFORE they program.

The Expedition Atlantis game pictured at the right is specifically designed to use robotics to teach mathematics.
Additional Virtual Tools

RVW Level Builder/Robot Transformer

The Level Builder enables teachers and students to make their own challenges using models that already exist.

Pictured below is an example of the NEW Robot Transformer Technology. Students can swap out robot parts and use them in the game.

Picture above from the New Expedition Atlantis Game
The Model Importer allows students to draw parts using a modeling software (i.e. PTC, Autodesk, Solidworks, or Google Sketchup) and save the part as an FBX file type and import that part into their custom Robot Virtual World.

Videos that show how this works can be found at: [www.robotvirtualworlds.com](http://www.robotvirtualworlds.com)
New Direct Launch File Type

Simplifies the user experience

1. Open Software
2. Choose Compiler Target
3. Open Program
4. Choose RVW
5. Log In To RVW
6. Play the Game

Older RVW software required the user to go through “six steps” to setup and play the game.

The new “Direct Launch Type” that we are developing automatically:

1. Opens ROBOTC
2. Selects virtual robots
3. Opens the program
4. Selects the correct world
5. Selects the correct robot type
6. And places the robot in the world.
Using Groups for Research

Published Research Can Be Found at: http://www.cs2n.org/teachers/research

Robotics Simulation Study with Hundreds of Schools
Teacher/Mentor Classroom View

Member Progress Teacher View

Individual Student Progress View
Teacher Grade Book View

Teacher View of Student Grades

Teacher View of Student Quiz Results

Teacher View of Overall Results

Grade Distribution

Number of students in group achieving grade ranges

Overall number of students achieving grade ranges
Computer Science Education Act – This Could Include Tech Ed

9/13/2013 – Referred to Subcommittee on Education
Future CS K-12STEM Offerings

The National Science Foundation Provides $5.2 Million Grant to Create New Advanced Placement® Computer Science Course and Exam

Innovative College-Level AP® Course Created To Increase Interest In Computing Degrees And Careers, Particularly Among Female And Minority Students

CollegeBoard

New Course and Exam — AP® Computer Science: Principles to Launch in Academic Year 2016–17

- Overview
- Development
- Higher Education Acceptance
- Curriculum and Assessment

The College Board plans to launch a new course, AP Computer Science Principles (CSP), in fall 2016, with the first AP CSP Exam scheduled to be administered in May 2017.

Carnegie Mellon Robotics Academy

Figure 1. Structure of a K-12 Computer Science Curriculum
This Could Be Us

Exploring Computer Science
With Robotics

joeyEinstein’s Coursework

joeyEinstein’s Artifacts and Evidence

Creativity  Abstraction  Data  Algorithms  Programming  Internet  Impact
Recruiting Partner Schools

To prepare over 1,000 Highly Competent robotics instructors able to teach students how to use robotics as an organizer to teach students engineering process and introduce students to the CS Principles Computational Thinking Practices identified as important for all students to understand (Astrachan, et al., 2009-2013); and to do so through their existing robotics classes.
Using Robotics to Teach Big Ideas of CS

The CS computational artifact for:

- **Creativity**: could be: a robot, a webpage, a logo for their team;
- **Abstraction**: pseudocode, variables, or a map;
- **Data**: the human genome, statistics on global warming, or collecting feedback from sensors via data logging;
- **Algorithms**: a flowchart, an algebraic expression, or an algorithm they developed to calculate a threshold value.
- **Programming**: robots that complete a variety of tasks
- **Internet and Impact**: Robotics competitions also involve team organization, fundraising, marketing, and team promotion, providing additional opportunities for students to create computational artifacts.
What’s in it for you?

• A Certification that could lead to Job Security
• Free training
• Free software
• An opportunity to be part of a research project
Certifying Coaches and Mentors

Online Training Tools
- Online LMS
- Extensive Resources
- Competition Specific Tools

Automated Assessment Tools
- RVW Curriculum Companion
- CS2N Groups
- CS2N Learns
- RVW CS2N Login

The Certification
- Computer Science and Robotics Certification

- Algorithmic Thinking
- Syntax, Statements, and Structures
- Robot Mathematics
- Control and Feedback of Motors and Sensors
- Boolean Algebra/Conditional Statements
- Variables/Functions/Parameters
- Pedagogy
- Programming User Interfaces
  - Buttons
  - Joystick
- Troubleshooting/Debugging Code
- Arrays
- Case Statements
- Multi-Tasking
- Multi-Robot Communications
- Pointers
- Recursion