Educational Robotics

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Goal: To enhance current science and math education through the development of a curriculum, materials and supplemental resources using the LEGO Mindstorms Invention System.

Background Theory

"Tell me I forget,
Show me I remember.
Let me do and I understand.."

Confucius 551-479 BC

Term	Founder	Highlights
Constructivism	Piaget	• Learning takes place as the result of mental construction by the learner. • Emphasis is placed on the learner and not the instructor. • Learner interacts with objects and events and thereby gains understanding of the features held by such objects and events • Learner constructs his/her own conceptualizations and solutions to problems. • Autonomy and intiative is encouraged
Constructionism	Papert	• "Giving children good things to *do* so that they can learn by doing much better than they could before." • Find ways in which the technology enables children to *use* knowledge, mathematical or other.

Cooperative Inquiry	University of Maryland	• Three step process:
		  ◦ Contxtual inquiry: observe how children interact with the technologies that are currently available.
		  ◦ Participatory design: Sketch ideas by building.
		  ◦ Technology Immersion: Expose children to technology that they might not encounter otherwise.

Learning by Design	Georgia Tech	• Students learn as a result of collaboratively engaging in design activities and reflecting appropriately on their experiences. • Learn science concepts through hands-on experience and real-world applications. • Incorporates teacher scaffolding to prevent classroom chaos. • Enhance problem-solving, decision making and collaboration skills.

Objectives

- Become comfortable with the LEGO Mindstorm Invention System and Tufts' RoboLab in order to:
  - Understand the technology
  - Anticipate technical difficulties
  - Identify fundamental concepts necessary to incorporate into the curriculum
  - Determine practical applications for the technology within the educational system

Development Process

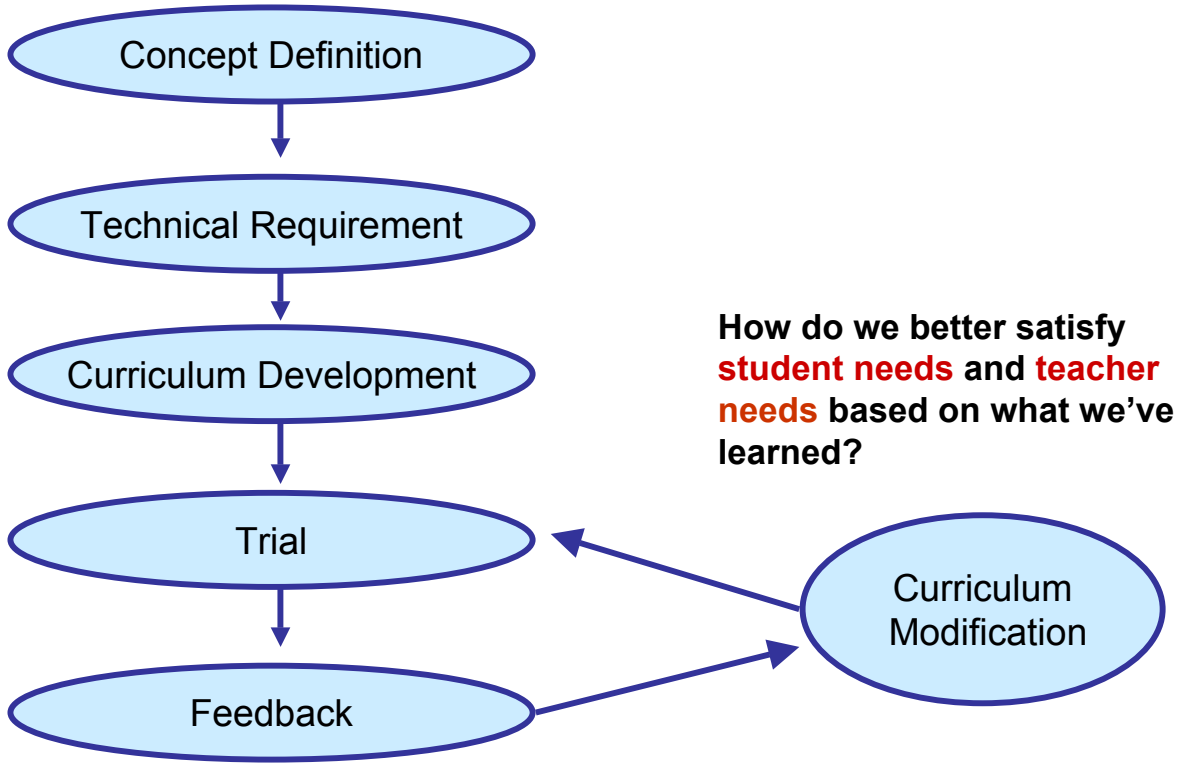
How can we integrate technology into the educational system?

What features/functionality/support would the teachers need?

How can we create a flexible and adaptable curriculum?

How can this be implemented in various environments?

Are students and teachers satisfied with the curriculum? Any problems?



How do we better satisfy student needs and teacher needs based on what we've learned?

Development (detailed)

- **Designed**
  - Preliminary curriculum
    - Lesson Plans
    - Challenges
  - Materials
    - Robotics Kit (subset of the LEGO Invention System)
    - Workbook
  - Supplemental Online Resources
- **Tested lesson plans and materials**
  - With different populations
  - In various environments
- **Evaluated with pre/post survey**
  - Level of ability
  - Level of interest
  - Cognitive processes
  - Feedback
- **Tailored curriculum and materials based on feedback**

Participants

Title	Audience	Type of Program
PS 164	6th Grade	School
STEP	9-12th Grade	Enhancement Program
Playing to Win	9-12th Grade	Community Center
GK-12	Teachers	Workshop

Program Comparisons

	PS 164	STEP	Playing to Win	GK-12
Location	• Washington Heights, NY	• Barnard College, NY	• Harlem, NY	• Columbia University, NY
Dates	• June 2003	• July 1 – 31, 2003	• July 14 – Aug 8, 2003	• August 18 – 23, 2003
Sessions	• 5 Lessons • 1 ½ hrs. per session	• 9 Lessons • 1 ½ hrs. per session	• 10 Lessons • 2 hrs. per session	• 8 Lessons • 2 ½ hrs. per session
Age	• 6th Grade	• 9-12th Grade	• 9-12th Grade	• Teachers
Gender	• 50/50 Males/Females	• 25/75 Males/Females	• 50/50 Males/Females	• 50/50 Males/Females
Group Size	• 4-5 Students	• 3-4 Students	• 1-2 Students	• 2 Teachers
Taught By	• Teacher + Undergrads	• 2 Undergrads	• 2 Undergrads	• 2 Undergrads

What was gained from …

PS 164

- Encountered numerous technical difficulties which we solved and documented.
- Acquired teaching techniques
  - ✓ Use real-world examples
  - ✓ Behavior management
  - ✓ Ability to abstract ideas

STEP

- First time all the challenges were tested
- Identified the gaps in the curriculum
- Realized that certain resources needed to be created as reference material for the students
  - Tips and Tricks
  - Cheat Sheet
- Recognized the value of having students keep a reflection journal

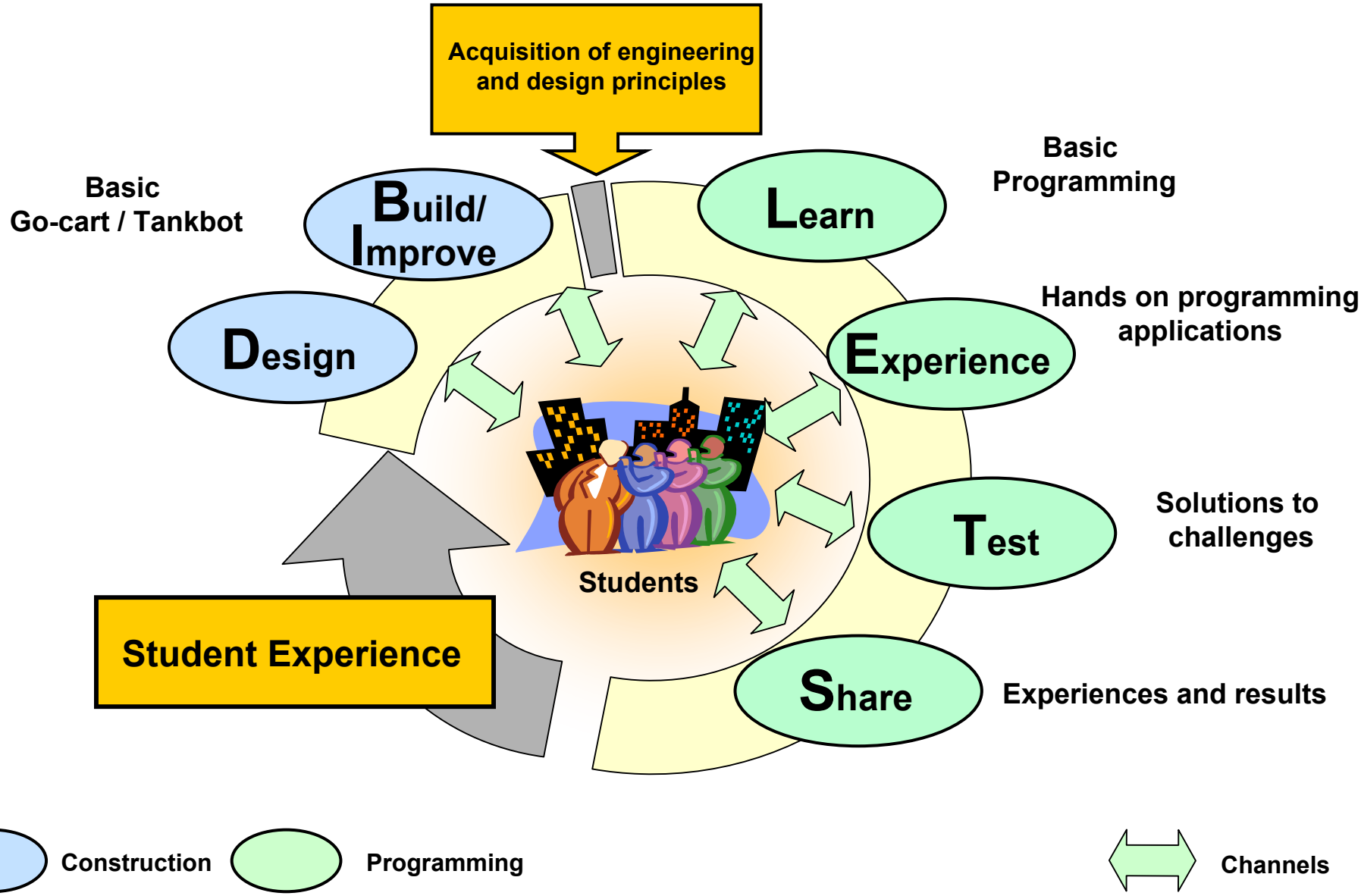
Playing To Win

- Obtained valuable feedback from fellow undergraduates using our lesson plans, materials and resources
- Encountered behavioral issues
- Despite behavior issues students "responded better in the robotics class than in any other"
- Found that disinterested students can be enticed to participate with 'cool' challenges

GK-12

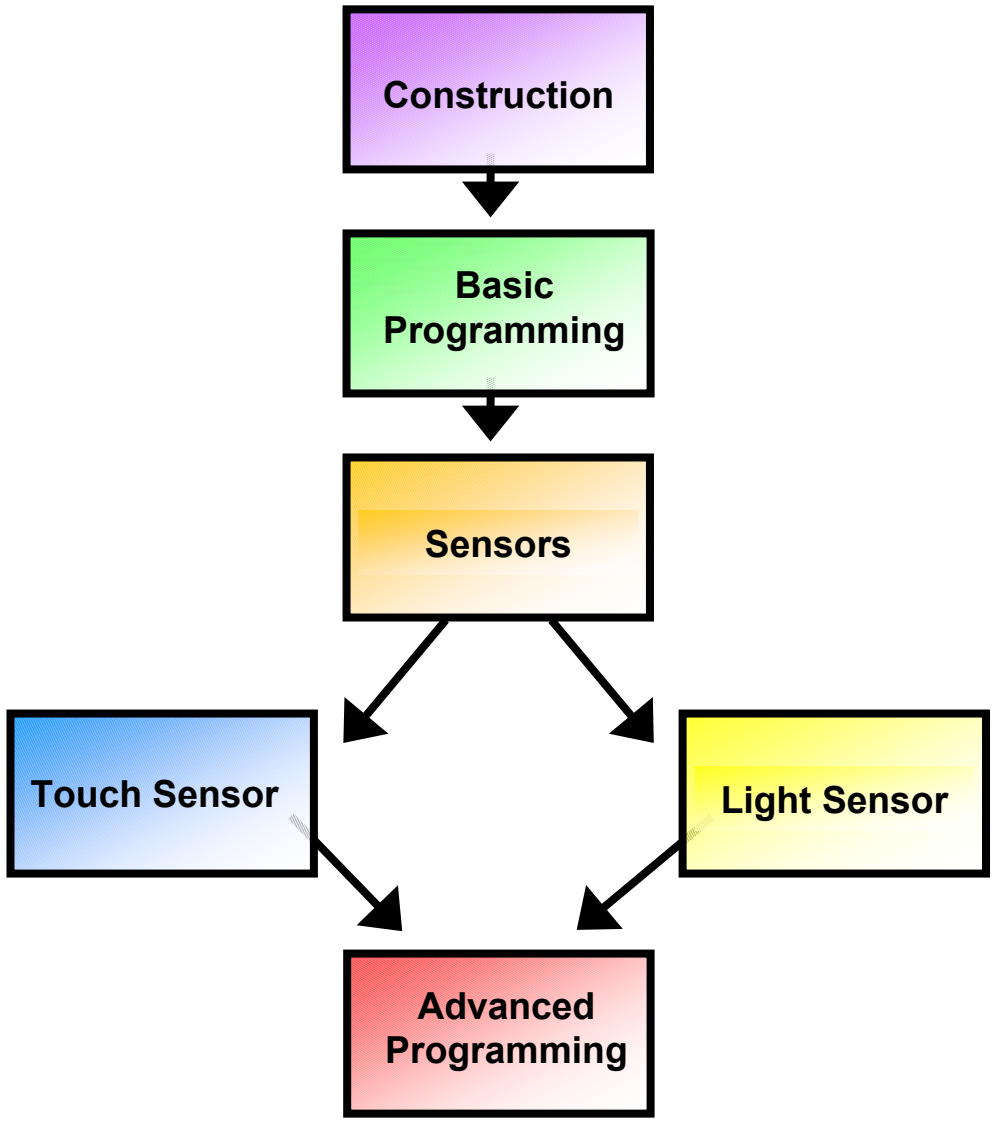
- Extremely valuable to present our work to experienced teachers
- Focused on potential problems and different strategies to solve them
- Discussed relevant applications of the technology within different math and science curriculum

Learning Process



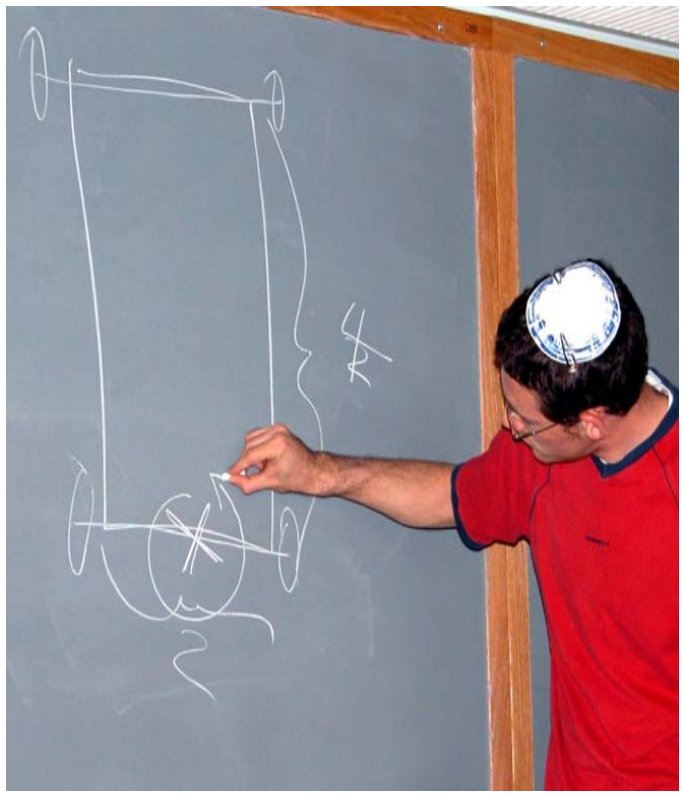
Technology Content

- **Construction**
  - Go-cart
  - Tankbot
- **Basic Programming**
  - Begin/End
  - Motors
  - Wait For Time
  - Stops
  - Music
- **Touch Sensor**
  - Wait Fors
  - Jumps
  - If / Else
  - Loops
- **Light Sensor**
  - Wait Fors
  - Jumps
  - If / Else
  - Loops
- **Advanced Programming**
  - Nested Structures
  - Using both light and touch sensors



Construction

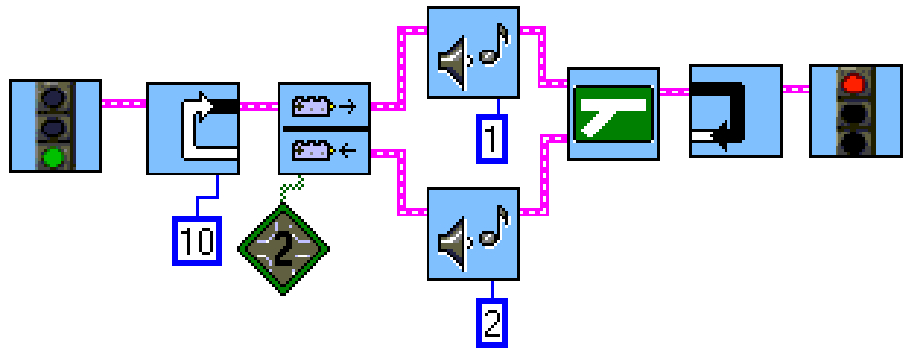
- Students design and build:
  - Go-cart → manual
  - Tankbot → automatic
- Students continuously improve their design
- Each iteration improves student understanding of the working dynamics of robots



Key Programming Concepts

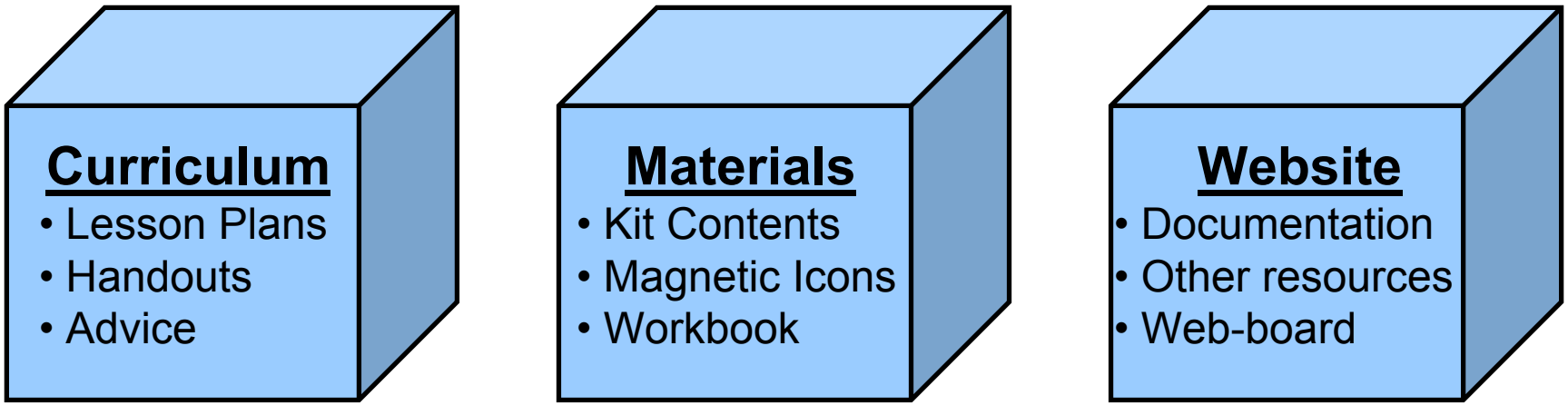
- Sequential Execution
- Ordering
- Logic
- Conditional Statements
- Repetition
- Nesting
- Debugging

Programming Example



This program will read the input from the touch sensor on port 2. If the touch sensor is released then sound #1 will play or else if the touch sensor is pressed then sound #2 will play. This will repeat 10 times.

Resources



Specifics

- Magnetic Robolab icons were developed to enable teachers to teach Robolab programming on the black / white – board
- A workbook was developed based on the various experiences. Included in the workbook:
  - Tips and Tricks
  - Cheat Sheet
  - Reflection Journal
- Documentation of the developed curriculum and materials can be found at:
  http://satchmo.cs.columbia.edu/er/curriculum
- Additional online robotic resources can be found at:
  http://satchmo.cs.columbia.edu/er

Future Research

- Analyzing all the data collected to ensure the success of the program
- Continued iteration of the curriculum
- Looking into different platforms compatible with the LEGO's RCX
- Continued development of a comprehensive and user-friendly website directed at both students and teachers