Programming Touch and Full-body Interaction with a Remotely Controlled Robot in a Secondary Education STEM Course

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Agenda

1. Introduction
2. Methodology
3. Findings
4. Conclusion
Introduction
Motivation

▪ Embodied Learning through sensorimotor modalities: touch, movement, speech, smell and vision (Barsalou 2008; Wilson 2002)

▪ Using the embodied approach to teach abstract concepts: STEM (Han and Black 2011; Lindgren et al. 2016) and computational thinking (Parmar et al. 2016)

▪ Development of digital technologies -> touch screen, gyroscope based hand gestures, speech, and computer vision based full-body interfaces (Jacob et al. 2008)

▪ Embodiment within robotics (Alimisis 2013)
Inspiration

- “Powerful Ideas in the Classroom” through programming with Squeak (Allen-Conn and Rose 2003)
- Expanding “beyond the screen”

<table>
<thead>
<tr>
<th>Powerful Ideas</th>
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</thead>
<tbody>
<tr>
<td><strong>Computational</strong></td>
</tr>
<tr>
<td>events, sequence, decision, loops, parameters, branches, problem-solving</td>
</tr>
<tr>
<td><strong>Engineering</strong></td>
</tr>
<tr>
<td>robotics, software engineering, sensors, speech recognition, computer vision, artificial intelligence</td>
</tr>
<tr>
<td><strong>Science</strong></td>
</tr>
<tr>
<td>speed, acceleration, heading</td>
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<tr>
<td><strong>Mathematics</strong></td>
</tr>
<tr>
<td>constants, variables, positive-negative numbers, absolute values, conditional statements, rotations in degrees, 2D coordinate systems, Boolean logic</td>
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</tbody>
</table>
Research Questions

- **Interface affordances for scientific exploration**: What kind of interaction modalities did students select for controlling the heading and speed of a robot and what were the criteria for their selections?

- **Comprehension**: Were there any differences in the development of students’ CT skills that could be attributed to the different types of embodiment?
Population

- Four-session robotic workshop
- Twenty-six school students (13 girls, 13 boys) from the third-level class of a middle school
- Students with little to no prior programming experience
- Students worked in pairs (10 same-gender and 3 mixed-gender)
- Study was conducted during the regular school time.
# Robotic Activities

<table>
<thead>
<tr>
<th>Activity Title</th>
<th>Students should create an application...</th>
<th>Computational Thinking Concepts</th>
<th>Scientific Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Touch Control</td>
<td>to control the robot with fingers by touching their phone screens</td>
<td>Events, Sequences, Data</td>
<td>Kinematics (heading and</td>
</tr>
<tr>
<td>Body Control</td>
<td>to control the robot with gestures, using computer technology</td>
<td>Events, Sequences, Loops, Data, Conditionals, Operators</td>
<td>Kinematics (heading and</td>
</tr>
<tr>
<td>Line Follow</td>
<td>to integrate Artificial to the robot so that it autonomously on the</td>
<td>Events, Sequences, Data, Conditionals, Operators</td>
<td>Kinematics (heading and</td>
</tr>
<tr>
<td>Project</td>
<td>to navigate a robot on a and hit an object</td>
<td>Sequences, Loops, Events, Parallelism, Conditionals, Operators</td>
<td>Kinematics (heading and</td>
</tr>
</tbody>
</table>
### Activities & Interaction Modalities

<table>
<thead>
<tr>
<th>Session</th>
<th>Activities</th>
<th>Interaction Modalities</th>
<th>Development Platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Remote Control</td>
<td>Touch</td>
<td>App Inventor</td>
</tr>
<tr>
<td>2</td>
<td>Body Control</td>
<td>Full Body Gestures</td>
<td>ScratchX</td>
</tr>
<tr>
<td>3</td>
<td>Line Follow</td>
<td>Artificial Intelligence</td>
<td>App Inventor</td>
</tr>
<tr>
<td>4</td>
<td>Project</td>
<td>Students’ Selections</td>
<td>App Inventor or ScratchX</td>
</tr>
</tbody>
</table>
Development Platforms

App Inventor

ScratchX with Kinect2Scratch and EV3 Extensions
Materials & Tools

- Kinect Sensor
- Lego Mindstorms Robots
Application Example

Student controlling a robot through a touchscreen interface
Application Example

Student controlling a robot through full-body interaction
Research Instruments

▪ “Again Again table” questionnaire
▪ Students’ projects in the final session were manually analyzed
▪ Camtasia capture of each of the students’ workstation screens
Findings
Activities Evaluation

Would you like to do the following activities again?

- Touch Control: Yes 15, Maybe 10, No 1
- Body Control: Yes 20, Maybe 4, No 2
- Line Follow: Yes 11, Maybe 7, No 1
- Project: Yes 23, Maybe 2, No 1

Legend: No, Maybe, Yes
Building Interfaces for Heading-Speed
Computational Concepts

![Computational Sophistication Chart]

- **Touch (N=5)**: 35.8 Programming Constructs, 14.8 Programming Patterns
- **Body (N=6)**: 31.5 Programming Constructs, 8 Programming Patterns
- **Autonomous (N=2)**: 33 Programming Constructs, 17 Programming Patterns

Legend:
- Blue: Programming Constructs
- Orange: Programming Patterns
Computational Practices

- being incremental and iterative, testing and debugging, reusing and remixing, and abstracting and modularizing

- compared the practices of two groups of students: Novice ($Constructs = 32, Patterns = 8$) vs Advanced ($Constructs = 36, Patterns = 17$)

- differences in their strategies
Conclusion
Conclusion

- Students chose interfaces that were attractive to them and congruent to the programming tasks
- Projects with the touchscreen interface sensorimotor and artificial intelligence were the most computational sophisticated
- Projects with the full body interface were the least sophisticated
Limitations

- The relative small sample (only thirteen projects were analyzed)
- Using a new technology (body) or a familiar interface (touch) for controlling the robot might influence students’ selections.
- Students were asked to deal with only three programming mechanics
- Project-based assessment was used for evaluating computational thinking
Future Work

Next possible steps:

▪ studying the effects of the embodiment on the comprehension of abstract STEM concept

▪ examine the use of different target platforms for the execution of code, such as wearables, humanoid robots or drones
Thanks for your attention!