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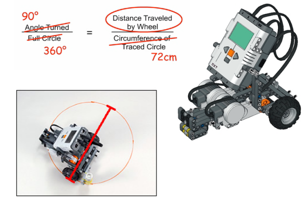
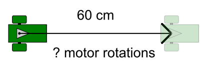
For more information:
http://www.robotics-academy.org/

The Robot Algebra Project

Robotics as a motivator and integrator for engaging 4th-8th grade students in using and understanding mathematics in technological design





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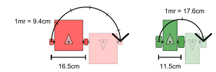

ITEST Collaborative Research Strategy Project NSF 09-506
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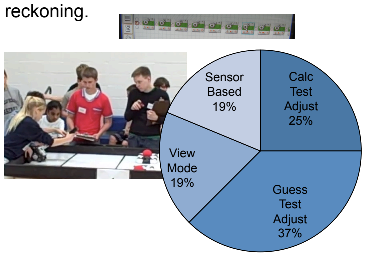
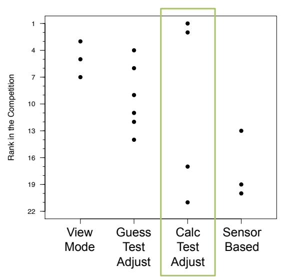
Competition Studies

What opportunities are there to use math in introductory robot design activities & does the math help?

In competitions, there are a range of strategies, but most teams don't use math (measurement or proportional reasoning) even though most teams use dead reckoning.



Lots of variability in success of the teams that do use math in their strategies (the two highest-scoring & two lower-scoring teams).



Opportunity to use math in basic robot movements (straights, turns, speed).

Conclusions

Competitions favor one-time solutions and tinkering, but math is relevant & can be helpful, although difficult to implement well.

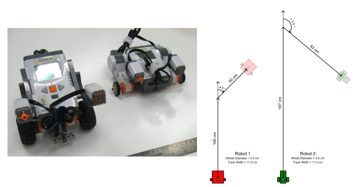
Silk, E. M., Higashi, R., & Schunn, C. D. (accepted). Resources for robot competition success: Assessing math use in grade-school-level engineering design. *Paper to be presented at the 2011 Annual Meeting of the American Society for Engineering Education*, Vancouver, BC, Canada.

Curriculum Design

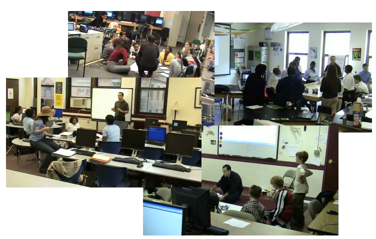
What kinds of instruction would help students engage with & learn about integrating math & robots?

Focus on **proportional reasoning** to understand relations between physical features, program parameters, & movement.

Model-eliciting activity (MEA) of ***Robot Synchronized Dancing*** (RSD) – a series of express-test-revise cycles in a design task



Implemented in many different types of classrooms (formal/informal, mixed/all girls, mixed/all minority, elementary/middle).



Observe increases in attitudes about the relevance of math for robotics without lowering interest levels.

Conclusions

Math can be integrated with robots in ways that maintain interest but encourage development of more formal ideas.

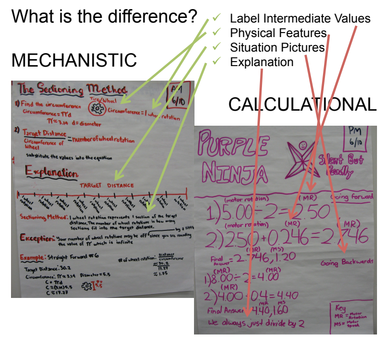
Silk, E. M., Higashi, R., Shoop, R., & Schunn, C. D. (2010). Designing technology activities that teach mathematics. *The Technology Teacher, 69*(4), pp. 21-27.

Learning Experiments

What are more productive ways for students to engage with & learn about integrating math & robots?

Mechanistic (physical quantities/actions) vs. **Calculational** (numerical values/operations)

What is the difference?



Mechanistic teams more likely to design higher-quality solutions – clearer, valid, fully-specified, and generalized.

Mechanistic teams more likely to transfer strategies from instruction to competition task rather than see them as unrelated.

Mechanistic Group

S1: We used the, the strategies that we learned all throughout the week. Um, we, like, for the straights, we, um, used the circumference of the wheel as the rotations and measured it, measured the area.

I: What do you mean by measured the area?

S2: Like how far it was from here to here. And then we like said, I think the wheel was 26 cm, so we said one rotation would be 26 cm, two would be whatever that is times two.

Calculational Group

S: Not really. No. Cause there isn't any, like, it isn't like we are comparing two different robots to do the same thing. All robots are the same in this. We're not using two different robots to do the same thing. So there really is no need for any strategies like that.

Conclusions

Math can be used as a thinking tool and can improve understanding when strongly connected to situations & represents ideas.

Silk, E. M., & Schunn, C. D. (accepted). Resources for learning robots: Facilitating the incorporation of mathematical models in students' engineering design strategies. *Paper to be presented at the 2011 Annual Meeting of the American Educational Research Association*, New Orleans, LA, United States.

Current Directions

Professional Development

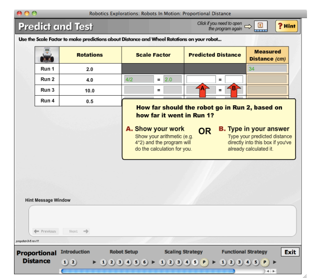
How can formal and informal educators be prepared to support integrating math & robots with diverse students?

Examining barriers to high-quality integration of math in robotics, including:

- teacher knowledge of math and robotics
- teacher knowledge of students' understanding of math and robotics
- teacher attitudes about the relationship between math and robotics
- teacher attitudes about the role of curricular materials in learning

Cognitive Tutors

Can we enhance learning through better student modeling of underlying skills, plus adaptive feedback & practice?



We are developing a series of units on understanding the math underlying simple robot movements:

- Measurement
- Proportional Patterns
- Mechanistic Proportional Relationships

We are targeting transfer of underlying proportional reasoning (relative change, covariance, invariance, and adaptive strategy selection) to non-robot contexts.